Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

84C
2

Circular No. 845

Management of Natural Slash Pine Stands in the Flatwoods of South Georgia and North Florida

by R. D. McCULLEY, Forester
Southeastern Forest Experiment Station
Forest Service

UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D.C. June 1950

LIBRARY
CURRENT SERIAL RECORD
JUL 25 1950
U.S. DEPARTMENT OF AGRICULTURE

Circular No. 845

June 1950 • Washington, D. C.

UNITED STATES DEPARTMENT OF AGRICULTURE

Management of Natural Slash Pine Stands in the Flatwoods of South Georgia and North Florida

By Robert D. McCulley, *Forester, Southeastern Forest Experiment Station, Forest Service*

CONTENTS

	Page
Introduction	1
Recent extension of slash pine stands	2
Importance of slash pine	4
Adaptation of slash pine to flatwoods sites	5
Management of naval stores timber for integrated production	5
Naval stores and wood products	6
Integration of grazing and timber production	12
Prescribed burning in the slash pine type	14
Recommendations for use of fire	15
Damage from prescribed fires	16
Problems commonly encountered	17
Growth and yield of a slash pine forest	19
Growth and yield of normal stands	19
Stocking, growth, and yield of managed stands	20
Silviculture of slash pine	21
Treatment of young unmerchantable stands	23
First commercial thinning	31
Further commercial thinning	37
Pruning	40
Reproduction cuttings	40
Summary	48
Literature cited	49
Additional references	51
Appendix	52

INTRODUCTION

A large part of the flatwoods forest of the Southeast has been taken over by slash pine (*Pinus caribaea* Morelet) in the past 20 years. In south Georgia and north Florida thousands of acres now support dense stands of young slash pine saplings. In this territory, slash pines large enough to be worked for gum or marketed for wood products have, until recently, been simply odd trees or groups of trees on the margins of a primarily longleaf pine forest. As such, they have

875203°—50——1

received no special consideration. They are turpentined to the same diameter limit, they are sawed or chopped into the same wood products, and, indeed, much of their wood is sold as longleaf pine. In the immediate future, however, landowners and forest managers in the flatwoods will be directing utilization of extensive forests of almost pure slash pine. In some localities that day is here.

The purpose of this publication is to present in usable form the results of experimental work and of experience so that management of these stands will be guided by the best and most up-to-date information available.

The term "flatwoods" indicates the area to which this publication refers. In local usage that name is associated with a definite forest condition. The soils are sandy, often underlain with hardpan, and poorly drained. Numerous shallow depressions store water for part of the year, but periodically they dry up. Tributary water courses are characteristically swampy. Low vegetation consists mainly of wire grass, saw-palmetto, and gallberry on the better drained areas; waxmyrtle, dwarf ("bluestem") palmetto, and gallberry grow on the margins of depressions. Merchantable timber is longleaf and slash pine, either alone or in mixture, on the better drained soils and slash pine, cypress, and hardwoods on poorly drained ones. The boundaries of the longleaf-slash-cypress timber type correspond in general with those of the flatwoods. Associated timbered areas, but with different timber growing conditions, are the deep sands, known locally as scrub oak ridges, and the heavier soils of the upper Coastal Plain.

Recent Extension of Slash Pine Stands

Success in reproducing young stands of slash pine is dependent upon fire control. Because its seedlings lack the longleaf's remarkable natural resistance to fire, slash pine until recently was confined to locations where ample soil moisture or standing water would protect it for part of the year (fig. 1). Where recent cutting has not altered the pattern, the seed trees which produced this fine crop of young growth may still be observed in their locations on the margins of swamps and in innumerable ponds[1] that characterize the flatwoods.

As soon as fire was at least partially removed as a hazard, the trees in these wet spots became the centers of rapidly expanding groups of reproduction. Because ponds and swamps commonly take up 25 to 30 percent of the land area in the flatwoods, there were many such groups which often merged to form a continuous stand of slash pine between ponds. On many acres where longleaf pine still holds sway in partially stocked stands, an understory of slash pine reproduction has already become established.

The range of slash pine (fig. 2) is thought by some to be extending itself naturally through seeding (*30*).[2] Numbers of plantations have been made north of the natural range. Some of these plantations are old enough to have produced viable seed (*40*, *48*), but the trees appear to be susceptible to damage from ice storms (*31*, *32*, *34*). Many plantations north and west of the range, as well as some within it on sites

[1] Shallow depressions, ordinarily with no outlet but holding water for only part of the year, which commonly support a stand of trees.

[2] Italic numbers in parentheses refer to Literature Cited, p. 49.

F–453381

FIGURE 1.—Slash pine in familiar surroundings. Water normally stands in this pond for half the year. Cypress forms a light understory. In the original forest slash pine was confined to the more poorly drained flatlands, but with the cutting of the virgin forests and with better fire protection it has spread widely over much of the flatwoods formerly dominated by longleaf pine.

not naturally occupied by slash pine, must be classed as failures because they are so heavily infected with fusiform rust.

Importance of Slash Pine

In the Southeast, species which replace valuable stands after cutting are usually inferior to the original growth of pine. One illustration is the growth of scrub oak on sandy ridges after the longleaf pine is removed. Another is the replacement of loblolly pine by low-grade hardwoods. Slash pine is an exception in this respect, as by almost every standard of comparison it is equal or superior to longleaf pine on flatwoods soils. It yields more gum, and because it forms less scrape the resulting naval stores products are of better grade.

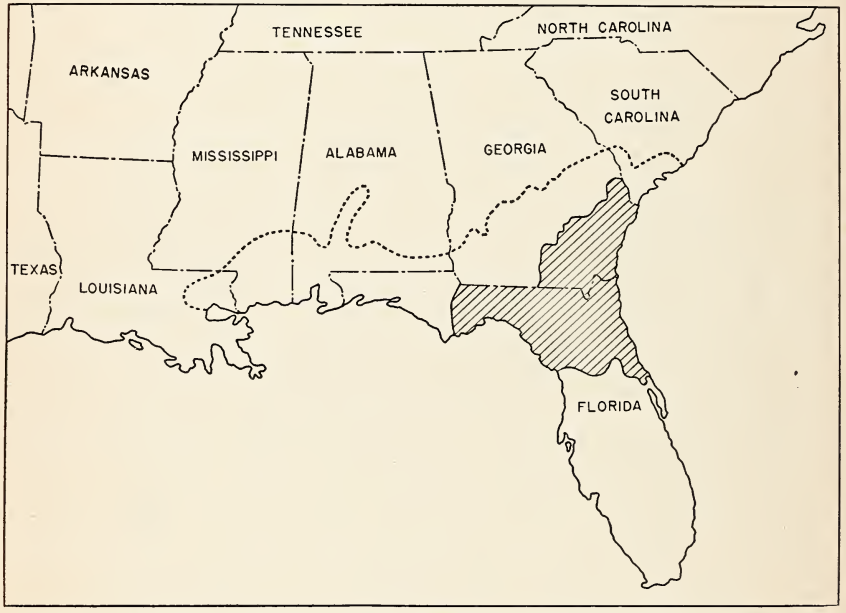


Figure 2.—Northern limit of natural slash pine and the area described in this circular. Slash pine also grows on the Caribbean islands and in Central America.

Slash and longleaf pine lumber with the same number of growth rings per inch is marketed without distinction as to species. Slash pine starts height growth in the first season after the seeds germinate and produces more volume per acre than longleaf pine at the same age. Slash pine responds more readily to almost every cultural treatment, its definite inferiority being its susceptibility to injury from fire during its early years. Taking all of these points into consideration, the change from longleaf pine to slash pine on the extremely sandy soils of the flatwoods can be considered only a desirable one.

Carried away by the ease with which young stands became established and the rapidity of juvenile growth, many early observers concluded that slash pine was a super tree that would revolutionize southern forestry. Such exaggeration has become a part of slash pine lore. Though not a wonder tree, slash pine is capable of good

yields of both wood and gum. The forest of the future in the flatwoods of south Georgia–north Florida will be a slash pine forest if the naval stores people, the sawmill people, and the pulp mill people have their way.

Adaptation of Slash Pine to Flatwoods Sites

Slash pine has so recently become important on soils with good drainage that there is still some question as to its ability to grow and reproduce itself where moisture is a critical factor. A classification of soil productivity, based on soil type and drainage, indicates very well the range of site conditions in the flatwoods. The classification may be readily applied in the woods by observing the plant indicators.

Observations show that slash pine stands are least productive on the deep, well-drained pure sands where scrub oak is mixed with pine. These areas are of limited extent in the flatwoods. Longleaf pine has been the only occupant of such soils until recently. Young plantations indicate, however, that slash pine will survive there. Its growth is slow, but that is to be expected from any tree on this type of soil. No greater number of fusiform rust cankers have been observed in these plantations than in those on better sites. Whether development will continue to be satisfactory as the trees grow into merchantable sizes is a question to be answered by further observation of the stands already established. Lands with extremely poor drainage ("crawfish flats") are also relatively unproductive, but slash pine appears to be as well suited to these conditions as any of the species with which it is associated.

Slightly more productive are the hardpan soils. These may be recognized by their dense covering of chlorotic (yellowish) palmetto and sparse gallberry. Slash pine in many places has seeded in naturally on these sites and is also growing reasonably well in plantations. Older trees, which by accident survived repeated fires, show that normal development can be expected in older stands.

A group of soils that are incompletely drained and characterized by a noticeable growth of gallberry, waxmyrtle, and occasional pitcherplants, make up the bulk of the better timber-producing sites. Slash pine grows well to saw-timber size and readily reproduces from seed on such areas.

Better growth is obtained in the shallow ponds and along the margins of deeper depressions where grass may be abundant. Difficulty is sometimes experienced, however, in obtaining full yields of pine from these sites because of competition from brush and hardwood trees during the regeneration period.

Slash pine stands on old fields can be expected to out-produce those on any woods site.

MANAGEMENT OF NAVAL STORES TIMBER FOR INTEGRATED PRODUCTION

A steady stream of products flows from the forests in the flatwoods section of south Georgia and north Florida. The regular output consists of sawlogs, naval stores, pulpwood, poles, piling, railroad cross ties, fuel wood, fence posts, veneer bolts, and even meat. Such diverse markets stimulate intensive woodland management (fig. 3).

FIGURE 3.—Products from the annual cut on the 53-acre Olustee woodlot typify the diverse markets available to flatwoods landowners.

They also bring their problems, as each of these products grows best under a restricted set of conditions that may give low yields for some of the others.

The forest manager's task is to so regulate his growing stock and forest practices that the maximum income results from a combination of products. This in itself is not simple. Where prescribed burning is used for protection, to stimulate forage production, and to better working conditions for woods labor, the job becomes more difficult.

The timber on most ownerships in south Georgia and north Florida is now worked for naval stores, but profitable operation of a slash pine forest is not dependent on gum farming. The declining demand for gum naval stores may soon cause emphasis to be shifted to production of wood. Many far-sighted landowners are giving thought to that prospect. The manager of a productive forest geared to meet the demands of a diversified group of industries has little to fear from such a change. He should be able to produce naval stores or not, depending on market conditions, without disrupting the flow of other products from his woods.

Naval Stores and Wood Products

The second-growth slash pine forests of the flatwoods at first were dedicated to gum production. Early thinning was aimed at the production of turpentine trees with large crowns. Timber growing received little thought or none at all. The efforts of Austin Cary and

others to introduce some of the lessons of integrated production from France were largely unavailing (*20*). Systems of selective cupping were proposed but seldom if ever followed.

With the rise of the pulp industry, the necessity for sawmills to turn from virgin timber to second growth, and the gradual decline of demand for naval stores, has come an increasing awareness of the competitive position of naval stores and wood products. These uses do not naturally complement each other. Rapid growth which produces wood with four growth rings or less to the inch is obtained at the expense of lumber or pulp values (*24*, *38*). Turpentine butts are not used for pulp but are used as fuel by some mills. They are seldom used for lumber below the last tin installation. The reaction of some landowners connected with the pulp and paper or lumber industries has been to bar turpentining from their lands. Where production of a specific raw material is the principal concern, this may be good practice. In the much more usual case, where dollar income from forest capital is the measure of success or failure, however, a compromise between exclusive production of either product may be the more lucrative solution. A frank recognition of the owner's needs and purposes is essential for an intelligent compromise.

EFFECT OF TURPENTINING ON GROWTH

Chipping a tree for naval stores reduces its growth. No comprehensive study has been made to determine the reduction in diameter growth, but fragmentary information suggests that it may be about 25 percent when one face is being worked and nearly 50 percent when a second or later face is being chipped (*10*, *17*, *21*). Cary (*10*) found the same percentage reduction in height growth. Recovery of normal growth after chipping stops is the exception rather than the rule. The effect of growth reduction is naturally to lower the yield of wood products. It also lowers their quality by making pulpwood trees out of many potential poles or sawlog trees.

EFFECT OF TURPENTINING ON MORTALITY

A number of trees are killed in naval stores operations, even by conservative turpentining on a relatively short cycle. Under the old methods of chipping high and deep on small trees, mortality was severe (*47*). Since the beginning of the Naval Stores Conservation Program, with its more conservative methods and turpentining confined to 9-inch, or larger, trees, mortality has been reduced. Annual mortality was 0.5 percent of the working trees in open stands on plots worked by the Southern Forest Experiment Station (*47*). Losses averaged only one-third of 1 percent per year for bark-chipped, acid-treated faces worked for 4 years on the Olustee Experimental Forest (*11*). For average conditions a figure of 1 percent annually is often used. Dense stands and long naval stores cycles both increase losses (*47*).

OTHER EFFECTS OF TURPENTINING

Other important results of turpentining include the loss of volume in jump-butts and the increase in cost of converting trees to logs or the finished product. At present the landowner does not always feel

the loss of pulpwood in jump-butts because many mills take them at the same price as pulpwood and use them for fuel. In sawlog or operations other than pulpwood in worked timber, much material is left in the woods as jump-butts. This is partly because of defects behind or above the naval stores faces (*45*) and often because of nails and tins left in the tree.

Stumpage prices for worked timber are lower than for comparable round timber owing to the extra cost of cutting off defective portions of the stem and to damage to tools from nails. Round timber can often be cut for two-thirds of the wages paid for cutting worked timber, where the number of saw cuts is the basis for piece rates. Older timber with ingrown nails often takes a heavy toll of crosscut saws. Even in timber with fairly fresh faces, it has been the experience on the Olustee Experimental Forest that few days go by that a saw crew does not hit at least one nail.

SELECTIVE CUPPING

Some of the effects of turpentining on wood production can be minimized by conservative naval stores practice. Others will be remedied only by a better selection of trees to be turpentined. Almost all turpentining is now done to a diameter limit (fig. 4). When cups are

F-444472

FIGURE 4.—Typical naval stores operation to a diameter limit. Under this system, trees are worked out before they have reached optimum sizes for wood or gum production, and their removal usually leaves a poorly distributed stand of small trees.

to be hung, all the trees with one face worked out are back-faced. Front faces are started on the trees that have grown into the minimum size for chipping. No attention is paid to a tree's possibilities for future wood growth, to its quality, or to the locations of other trees in the stand. Cutting the worked-out trees resulting from such an operation often leaves a poorly distributed stand of low-quality growing stock.

A different method of selecting trees for chipping has greater promise. More emphasis is placed on quality and productivity of the stand and much less on tree size alone. By this method, trees in a stand are marked for cupping in accordance with definite plans for meeting silvicultural requirements. This means that during the intermediate stages of stand development the better quality trees are left round to grow to larger, more valuable sizes while their less promising neighbors are chipped and cut. Whichever silvicultural system is used, cupping is confined to trees that for one reason or another have been marked for removal from the stand.

The practice of turpentining marked trees only is known as selective cupping (fig. 5). Foresters in the South have recognized for

F-453380

FIGURE 5.—Selective cupping before an intermediate thinning. Faces are visible on working trees. Crosses designate better quality trees reserved for further growth and later cupping when they have reached more productive sizes.

20 years that the barest essentials of forest management require this practice (*14*, *19*). However, outside of the Florida National Forests there are few examples of it because selective cupping temporarily reduces the landowner's current income. Many turpentine operators

question whether such an operation could be made to pay. Labor and tradition both support the diameter-limit system, and selective cupping requires a type of supervision which has been lacking.

The growing relative importance of wood is forcing a careful consideration of selective cupping. That this practice results in larger, higher-quality yields of wood products is self-evident. What may have been overlooked is that it is also good business from the naval stores viewpoint alone.

Selective cupping, followed through several cutting cycles, offers a means of producing larger trees and more working faces per acre. A 12-inch tree yields half again as much gum as one 9 inches in diameter (table 5 in appendix). Still greater yields can be expected from larger trees. These extra yields are worth striving for. They come only by accident on a limited basis under the diameter-limit system. But they are included in any reasonable plan for selective cupping (fig. 6).

F-453379

FIGURE 6.—Selective cupping before harvest which will leave a shelterwood of about 25 trees per acre. Shelterwood trees, marked by crosses, are being worked on one face; all other trees have two cups. Large trees such as these enhance the value of the final harvest.

During a stand rotation, more trees per acre will be brought to profitable turpentining size through selective cupping because it is more efficient than chance determination of which trees are to be cupped. Openings too small for reproduction are common in diameter-limit stands. So are isolated individuals or small groups of trees too far from others of workable size to be operable. Proper selection of trees to be cupped will avoid both of these conditions.

INTEGRATION OF CUTTING AND TURPENTINING

Most landowners in the flatwoods of north Florida and south Georgia will be interested in producing both gum and wood products on their land if such use will yield more income than straight wood or gum forestry (fig. 7). The emphasis will vary from one ownership to another, depending on whether faces are leased or worked by the owner's labor, and whether the landowner is tied in with processing plants. Regardless of the emphasis, however, the following are proved methods of integrating the two uses so that a reasonable compromise results.

Selection of trees.—Selective cupping is the cornerstone without which there can be no true integration of turpentining and wood production.

Reduction of mortality through conservative naval stores methods.—Most current naval stores work is conservative and does not usually cause high mortality among turpentined trees. Weekly chipping one-half inch high and one-half inch deep is conservative in this respect. So is the use of sulfuric acid with either one-half-inch-into-the-wood chipping or bark chipping at 2- or 3-week intervals (*12*). Rapid tapping, employing weekly chipping and acid, is safe for a restricted period in young timber badly in need of thinning. However, the increase in gum yield attributable to weekly acid treatment may decline after the first year.

Conversion of entire stem into wood products.—Very few of the current tin installations allow satisfactory use of the butt portion for wood. Nails seem to be a necessity on turpentine faces and operators will not remove them unless forced to do so. A requirement that nails and tins be removed after trees are worked out should become regular practice in the management of naval stores timber.

Limitation of number and height of faces.—Short naval stores cycles—5 years or less—are necessary to keep the turpentine butt in shape for conversion to wood products, to allow stands to be thinned at proper intervals, and to avoid the mortality and degrade synonymous with high faces (*45*). Use of a tree for no more than two cycles is an additional measure designed to keep turpentine butts from deteriorating. Biweekly chipping with acid treatment is a natural adjunct of integrated production because the height of faces is reduced below the usual requirement without reducing yield.

Removal of faced trees.—Trees with faces on them should be producing, not simply taking up growing space. The results of an effort to extract the last ounce of gum from trees before they are cut are evident on almost any property in the flatwoods. Trees saved in the hope of getting another face on them are poor risks and might better have been cut to make way for new growth. The productive naval stores forest is a young, vigorous forest. These old cripples add little to income.

F–453386

FIGURE 7.—Selective cupping provides 140 faces per acre before an intermediate cut in this 20-year-old plantation. After cutting there will be 176 trees of better quality to grow to larger size. Diameter-limit cupping in a plantation may take almost every tree.

INTEGRATION OF GRAZING AND TIMBER PRODUCTION

Most of the forest land in the flatwoods is grazed by the landowner's or other people's cattle. Consequently most slash pine landowners are interested in possible supplemental income from cattle. These returns will not be large, as the native forage is poor except in the spring after it has been burned and improved breeds do not thrive on it as a yearlong diet. With the type of management now practiced, calf crops averaging well below 50 percent are the rule, because cows are

too poor to breed when suckling a calf and therefore tend to calve only on alternate years. Herd management is generally primitive, but some people have started feeding mineral supplements yearlong, feeding concentrates in winter, controlling the breeding season, and using purebred bulls. These improvements have been credited in some cases with doubling the calf crop.

The woods of south Georgia and north Florida produce a tremendous amount of grass. However, most of it is unpalatable and lacking in food value if left unburned. Two native species—pineland three-awn and Curtiss dropseed, which are commonly lumped together and called wire grass—make up a large part of the grass cover (*8*). Other species are relatively unimportant in the area each covers, but on the average they are more palatable than wire grass and furnish needed food value. Carpetgrass, a palatable exotic species, has in recent years become established on heavily grazed or disturbed sites, particularly around ponds, on fire lanes and woods roads, and in old fields. Wherever carpetgrass produces a sod, it is closely grazed and fire hazard is reduced to a minimum.

Flatwoods wire grass range is improved by burning in the winter or early spring (*15*, *16*, *27*). More forage is made available and the mineral and protein content is higher on freshly burned range than in older roughs. This effect usually lasts from March till the middle of June. During the late summer, fall, and winter cattle usually gain little weight or gradually lose. Legumes are encouraged by the use of fire.

Maximum use of winter-burned range in spring and early summer appears to be good management of the forage in a slash pine forest. Cattlemen consider the burning of a third or more of the available range as good practice, but the requirements for timber production may force a reduction in this amount. Experience has shown that prescribed fires almost invariably cause some damage to standing timber unless the area burned is small and the timber uniform. Costs of burning these small tracts are high. Repeated burning at short intervals can therefore be expected to total up a relatively large charge for cumulative damage or for burning of small units.

The need for slash pine reproduction is another and more important reason for restricting the area to be burned each year. The Olustee Experimental Forest is better stocked with timber than most other lands in the flatwoods, but requirements for reproduction and experience with damage in "hot spots" of fires which had been carefully set led to the conclusion that burning of only 10 to 15 percent of the area each year is consistent with good forestry practice. Cattle stocking should be adjusted to the carrying capacity of the area burned each year.

With only native range and "pineywoods cows," experience on the Olustee indicates that a landowner can afford to spend very little on fences or other improvements. In the management of his land he would be justified in making very few concessions to benefit the cattle. Prescribed burning should be done for protection and other purposes and only incidentally for the cattle. About 50 acres per head will be required under extensive herd management without improved pasture and with burning keyed to the needs of the timber, not of the cattle.

If enough supplemental feed is provided during the months when the nutritive value of native range is deficient, a better grade of cattle can be produced and yields will be higher than with current practice. Seasonal grazing of farm woodland is an example of this type of use. If the forest owner has no nonforest land on which to grow feed, and most flatwoods landowners do not, the cost of feed required to carry a herd for several months will be high. Feeding schedules have not been tested sufficiently and the relationship between cost of feed and returns in beef have not yet been well enough established to permit recommendation of any program especially adapted to the needs of these landowners. Results of current studies strongly indicate, however, that a protein supplement will be required during the fall and winter to avoid excessive death losses.

Grazing, alone, does little damage to slash pine stands. On the other hand, it can be a real benefit to timber production by reducing the build-up of fuel on prescribed burns.[3] Investigations at the Georgia Coastal Plain Experiment Station (*16*) showed that grazing during the first 2 years after burning reduced fuel accumulation 30 percent the first year and 45 percent for the 2-year period.

Carpetgrass is easily established on flatwoods soils but is not regarded highly as forage by many pasture experts. However, as it is palatable without burning and endures close grazing, this species could well be encouraged strictly from the standpoint of fire protection. To produce high-quality forage on flatwoods soils, however, additional nitrogen must be supplied to the grass by fertilizing or by establishing with it a legume, which also requires fertilization.

It has been suggested that as much as 20 percent of the area of an individual property might profitably be sown to pasture grasses as a means of integrating forestry and grazing (*36*). The pasture would consist of wide strips through the forest property, serving as firebreaks. Such a plan might apply on the better soils in the flatwoods.

PRESCRIBED BURNING IN THE SLASH PINE TYPE

Fire protection in the flatwoods brought with it the invasion of drier sites by slash pine. It also built up the fuel on the ground, while gallberry and palmetto undergrowth increased in size and density. The result was an extremely hazardous accumulation of fuel. Fires in such a "rough" spread rapidly and are hard to control. In the occasional "dry" year, which can be expected periodically in south Georgia and north Florida, the situation builds up to a peak and may get out of control.

The conventional fire protection system, a prime factor in forest production in the flatwoods as elsewhere in the Southeast, consists of a detection network of lookout towers, suppression crews with hand tools, fire line plows, tank trucks, and a grid of preplowed fire lines from which to backfire. The forest services of both Georgia and Florida provide a framework upon which to build a suppression

[3] The application of fire to land under such conditions of weather, soil moisture, time of day, and other factors as presumably will result in the intensity of heat and spread required for specific silvicultural, wildlife, grazing, or fire-hazard reduction purposes. A more precise term than "controlled burning," although the two are often interchangeable in local usage.

organization in most of the counties where forest production is very important. The areas in which they operate are rapidly being expanded, and their efforts have generally reduced area burned to a reasonable figure.

The difficulty has been that several years of successful protection have sometimes been followed by severe fires during a dry season when control was difficult and seemed impossible. For the individual forest landowner this might mean disaster.

Controlled burning has been a common substitute for other means of fire protection since the early days of the naval stores industry. Most foresters held it in low esteem for a long time because slash pine needed complete protection for a number of years in order to get established, and much destructive burning was called controlled burning. The gradual shift to the opinion that fire might be used under certain conditions with beneficial results came only after investigation of the effect of fire on the soil and on timber values. Heyward and Barnette (*23*) found that soils in the naval stores region were not noticeably damaged by repeated fires. Their analysis of samples indicated that soils on burned areas were slightly richer in plant nutrients than similar soils in protected areas. A compacting of the surface was noted on burned areas. Greene (*15*) found similar chemical relationships at McNeill, Miss. The essential relationships between fire injury and growth of naval stores pines have been developed over a period of time. In 1943, Bickford and Curry (*3*) published tentative estimates of the effect of scorching on subsequent growth and mortality. A major factor in the development of prescribed burning practice in the flatwoods was an investigation of methods for carrying on prescribed burning on a large scale.

Recommendations for Use of Fire

Bickford and Newcomb (*4*) found that successive steps in successful burning should be: (1) Thorough analysis of a forest property to determine whether fire could be used with benefit; (2) advance planning, which includes selection of areas to be burned and description of methods to be used; (3) preparation for burning, which includes plowing of fire lines and training of crews; (4) the actual job of setting fire on the selected day; and (5) an appraisal of results as shown by condition of trees after the fire. On smaller pieces of land known intimately by the owner or forester in charge, much of the information needed is known in advance.

It was found on the Osceola National Forest that burning could be done most successfully between December 15 and February 15. All preliminary steps were completed by early fall. Plowing of lines preceded burning by not more than 2 weeks, so that fallen needles would not cause break-overs. Good burning conditions consisted of a 3- to 10-mile northerly wind in clear weather usually 1 or 2 days after a rain. Burning was limited to days on which a constant wind direction was forecast. A crew of 5, including the leader, was most efficient. Reasonable cost in relation to benefits required burning of not less than 10 acres per man-hour.

Best results were achieved by using backfire set on east-west plowed lines spaced about 10 chains apart. Costs were reduced by spread-

ing fire rapidly, so that 10 or more miles were burning at one time, and by the use of relief crews to take advantage of favorable burning weather.

Damage From Prescribed Fires

The success of burning has been judged entirely by the proportion of brown needles observed on the trees after a fire. Recent investigations [4] showed that slash pine less than 3 inches in diameter lost diameter growth even when there was no scorching (fig. 8). Un-

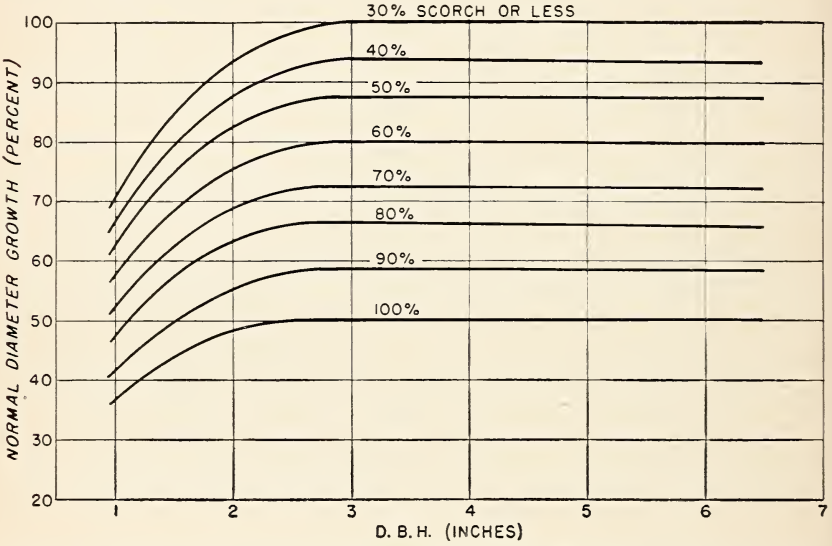


Figure 8.—Percent of normal diameter growth of slash pine, by diameter and scorch classes, for a 3-year period following prescribed fire.

scorched trees 7 inches or less in diameter lost height growth after burning (fig. 9). Scorching of up to one-third of the crown further reduced growth in height but did not affect diameter growth. Increasing loss of growth in both diameter and height accompanied greater scorching. Within 3 years after injury, growth in diameter had returned to normal, except for trees in the 2-inch diameter class with more than 80 percent of the crown scorched and for those with less scorch in the 1-inch diameter class. Recovery of normal height growth seems to be a much slower process, about which there is little specific information. In the study cited, no recovery of height growth could be detected 3 years after burning.

---

[4] Mann, James M. The influence of fuel, size of tree, and type of fire on the mortality and growth of longleaf and slash pine on the Osceola National Forest. 47 pp., illus. 1947. [Unpublished rpt. on file at U. S. Forest Serv. Southeast. Forest Expt. Sta.]

McCulley, Robert D. Progress report on a study of the significant factors affecting fire injury and the effect of such injury on the mortality and growth of slash pine on the Osceola National Forest. 27 pp., illus. 1948. [On file at U. S. Forest Serv. Southeast. Forest Expt. Sta.]

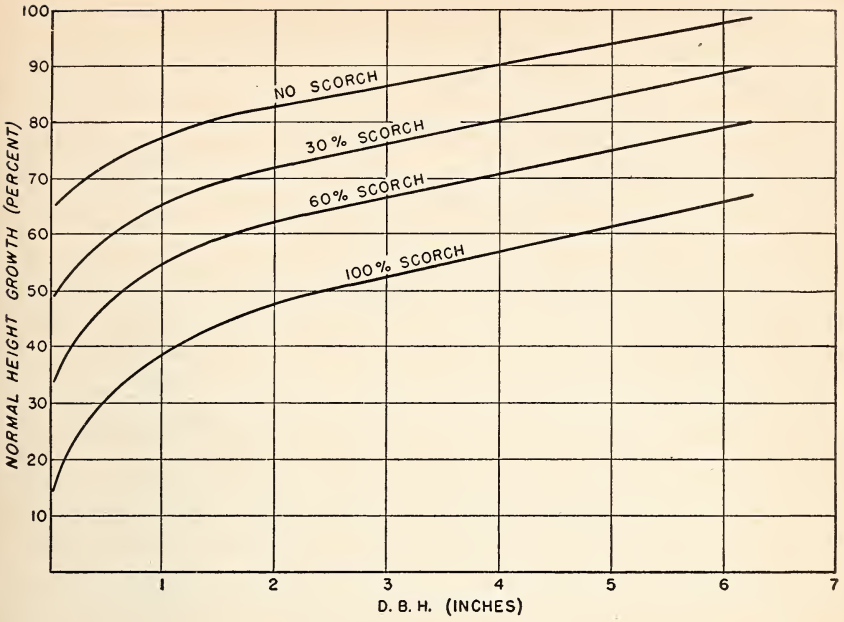


FIGURE 9.—Percent of normal height growth of slash pine, by diameter and scorch classes, for a 3-year period following prescribed fire.

Growth losses may be important components of damage, but most of the damage from burning consists of mortality. Slash pines with less than 70 percent of the crown scorched seldom die if they are more than 5 feet tall. Greater scorching results in mortality, and when part of the crown is consumed by the flames the percentage of mortality increases rapidly (fig. 10). Backfires used in stands where trees are about 3 inches in diameter (20 feet tall) or larger seldom result in sufficient crown scorch to cause mortality or significant growth loss. Use of fire in smaller timber increases the risk of more serious loss.

In the study of fire damage on the Osceola National Forest, more damage was caused by backfire in a grass fuel than in pine-needle litter. This difference disappeared where fire was running before the wind. Whether the fire was running with the wind or against it, and whatever the type of fuel, open stands with less than 300 stems per acre were damaged more heavily than dense stands.

PROBLEMS COMMONLY ENCOUNTERED

Fire is a dangerous tool and a very destructive one when improperly used. It should be prescribed for a particular purpose. The measure of its success is the degree to which that purpose is achieved without severe damage. In slash pine territory in the flatwoods, the object of burning is primarily protection. With proper use it can aid materially in fire control and at reasonable cost. Improperly used, it insidiously reduces management profits.

875203°—50——3

One means of controlling damage is to burn each year only as large an area as is absolutely necessary for an adequate protection pattern. A system of barriers against the spread of large fires is one result of good planning. The history of fire in each locality will serve as a guide to the adequacy of any proposed system.

Another method of reducing damage is to avoid burning where trees are too small. Under the best conditions fire can be backed under a 6-foot slash pine with only the loss of growth in diameter and height which accompanies any fire in small timber. This has led to the opinion that 6 feet is an acceptable height for burning (*4*). But such optimism may lead to excessive damage. Investigation has shown that a safer minimum is 12 feet. Where possible it should be raised to 15 feet. Restricted areas of small timber may be plowed out of the burn at a saving if they can be efficiently reached by the tractor and plow (*44*).

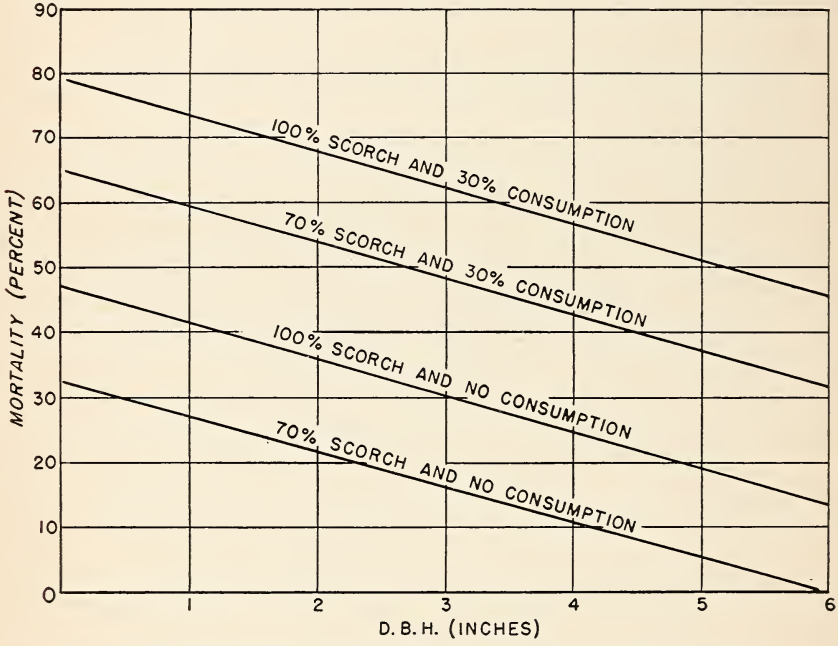


FIGURE 10.—Relationship of diameter, scorch, and needle consumption to mortality of slash pine.

Cycle burning (burning any particular area at regular intervals) is poor burning. Fire should be used for a reason, and mere passage of time is not a good reason. Well-developed stands might need to be burned at fairly frequent intervals to protect an adjacent reproducing area (fig. 11). Where reproduction is desired, experience at the Olustee Experimental Forest indicates, no less than 10 years of complete protection must be provided if a full stand is to develop. Burning at 5-year intervals often prevents establishment of slash pine reproduction.

F-344719

FIGURE 11.—Prescribed fire backing into the wind through a light fuel. Such areas may be easily burned without damage.

The use of fire is not an end in itself and unless progress is being made toward the true objective, so-called prescribed burning will be a wasteful, destructive process, inferior to reasonable efforts directed toward complete protection. Therefore, acreage quotas, whether imposed arbitrarily or by the needs of cattle, should be such that they can be easily met without burning that results in excessive damage.

GROWTH AND YIELD OF A SLASH PINE FOREST

Growth and Yield of Normal Stands

The yield and stand tables prepared for second-growth slash pine give statistics for heavily stocked stands which have developed naturally without cutting (*13*, *46*). The principal weakness of the tables is that they depend upon a method of site quality determination (based on the average height of dominant and codominant trees at 50 years) which lacks precision in flatwoods stands. One reason this gage of productive capacity may be inaccurate is that fire injury, which is not uncommon in this locality, may reduce height by as much as 20 feet at 50 years (*50*). Also, where the stand has not been injured by fire, height growth on the poorer sites may be comparable to that on better sites during the early years. The Raiford, Fla., plots illustrate this point. Fifteen years ago, when the trees were young, a well-drained plot showed a higher site index than adjacent moist

plots because of rapid juvenile height growth of the trees. Today the plots have almost identical site indexes, but there is every indication that at stand age 50 the wet plots will be far ahead in site quality. The site index for the well-drained plot has steadily decreased as new estimates have been made over the years.

Despite these shortcomings, the normal yield tables, when properly qualified by a recognition of errors involved, furnish the least expensive approximations for the yield of wood from unmanaged stands (appendix, table 4). There are no such tables for gum yields. The nearest approach is a table giving gum yields by diameter for good and poor sites (appendix, table 5).

On sites with an index of 70, about average for the flatwoods, the yield tables show that average annual production in cords peaks at an early age and falls off gradually in stands over 20 years old. This rapid early growth is of interest particularly to pulp mill foresters and others concerned with quick liquidation of management costs. The volume production per acre in these young stands is not phenomenal, but for sites comparable to those in the flatwoods the yield tables give values for slash pine a little higher than for other southern pines in stands less than 40 years old. For a rotation of 35 years on a 70-foot site they show that an average of 21 cords per acre distributed in an adequate series of age classes will yield 1⅔ cords per acre per year.

Board-foot yields given for slash pine are generally lower than those for loblolly and shortleaf pines, but they exceed the yields for longleaf pine up to 60 years of age on the poorer sites. On one of the better sites on the Olustee Experimental Forest near Lake City, Fla., a full stand of slash pine contains 30,000 board feet (Scribner) per acre at 60 years of age. Average annual board-foot (Scribner) growth for site index 70 reaches its maximum at about age 60. A tract of slash pine, site index 70, with fully stocked stands and a complete series of evenly distributed age classes will produce 290 board feet per acre per year on sustained yield, if a 60-year rotation is used (appendix, table 4). Over the whole of such a tract the growing stock will average about 6,000 board feet per acre.

Stocking, Growth, and Yield of Managed Stands

In a forest under management, yields differ materially from those given for normal stands. Managed stands have fewer trees per acre because a better return on invested capital is obtained with less growing stock. Natural losses result in irregular distribution and reduced growing stock. Periodic cutting also has a variable effect on yields. The normal yield tables, therefore, will give inaccurate approximations for managed stands unless adjustments are made. Correction for percent stocking is the most obvious adjustment needed. Others may be required to refine the estimate.

On almost every tract the present volume of growing stock is too low to permit satisfactory sustained wood or gum production. The Forest Survey estimated in 1946 that there were 8 cords on the average acre in south Georgia and 5 cords in north Florida. For reasonably adequate production much greater volume is required. On the Olustee woodlot where naval stores is to be the primary product on a rotation of approximately 45 years, it is estimated that a growing stock of not

less than 15 to 20 cords will be required (*29*). One of the first goals of management should be to build up the growing stock to a level that will sustain high yields.

Records for stands under management give some indication of the yields that may be anticipated from slash pine in various degrees of stocking. Only enough data are at hand, however, to provide sketchy information about growth in cords (table 1). Estimates of naval stores yields and board-foot yields must be made with even less factual information to support them.

Allowing for the fact that production records have been kept only for better than average stands growing on relatively good sites, the average figure of 1 cord per acre per year, often used for forest land in this territory (*49*), appears reasonable. On hardpan lands only about 0.5 cord per acre per year may be produced with good management. Two cords or more per acre per year may be possible on the best sites if the timber is grown on a short rotation.

Where the emphasis is on naval stores, less growing stock will ordinarily be carried because trees should reach chipping size in vigorous condition for gum production. Computations based on the Olustee woodlot indicate that after a growing stock of 20 cords is built up an average of more than 50 naval stores faces per acre can be kept working continuously.

Controlled cutting has a greater effect on board-foot yields than on cordwood or naval stores production. As a result, estimates of growing stock needs based on normal yield tables will probably be too high for managed stands. Additional research and experience are needed before desirable levels can be set exactly. For the present, a volume approximating 5 thousand board feet (Scribner) per acre appears about right for a 60-year rotation on a 70-foot site. If an allowance is made for turpentining and pond areas, it is estimated that yields in a well-stocked and intensively managed forest may be close to 250 board feet (Scribner) per acre per year.

SILVICULTURE OF SLASH PINE

Some species give much more promise for intensive management than others, not simply because they produce more valuable products, but also because they are sensitive to changes in their environment and adjust readily to them. Full use of the growing space can be made with such an adaptable species. Thinnings will produce a rapid growth response in the trees left, and small openings too large to be used efficiently by border trees will fill in with reproduction. Within limits, slash pine has these characteristics.

Any general description of slash pine should picture a tree that is relatively easy to grow; one that responds well to cultural treatment. Trees 30 to 40 years old produce some seed almost every year and fair to good crops at frequent intervals. No special ground preparation is required for adequate germination and establishment on most sites. Response to thinning in young stands is prompt, but there is some indication that stagnation may result if older trees are not kept in good growing condition.

Insects seldom attack slash pine except after logging, and such damage can be held within bounds by reasonable precautions. The only disease which now threatens to limit production of slash pine

TABLE 1.—*Cordwood yields from slash pine stands of varying age, density, and cutting history*

Site and age of stands (years)	Trees per acre	Average diameter, 100 largest trees	Basal area	Volume of trees 3.5 inches d. b. h. and larger		
				Standing	Cut	Total
SITE INDEX 80						
Pond margin:						
Stand 1:	*Number*	*Inches*	*Square feet*	*Cords*	*Cords*	*Cords*
8	210	3.8	13	0	0	0
18	170	9.4	65	13	0	13
23	170	10.2	70	17	0	17
Stand 2:						
8	385	3.6	17	0	0	0
18	325	8.6	90	12	6	18
23	240	9.4	76	18	0	24
Stand 3:						
8	720	3.4	31	0	0	0
18	630	7.9	131	16	9	25
23	500	8.9	119	25	0	34
Stand 4:						
8	3,480	3.5	79	0	0	0
18	1,440	6.8	162	21	6	27
23	1,070	7.7	140	24	0	30
SITE INDEX 72						
Old field:						
Stand 5:						
25	605	7.8	107	20	11	31
29	470	8.2	104	24	0	35
31	400	8.4	100	26	0	37
35	360	8.9	109	30	0	41
42	350	9.8	126	39	0	50
Stand 6:						
25	1,047	8.0	161	31	0	31
29	877	8.4	157	34	0	34
31	783	8.7	154	37	0	37
35	630	9.0	145	39	0	39
42	539	9.9	154	45	0	45
SITE INDEX 90–95						
Shallow pond:						
Stand 7:						
16	254	5.9	37	4	3	7
20	254	7.4	61	11	0	14
26	254	9.5	101	28	0	31
31	179	10.8	99	35	10	48
Stand 8:						
16	2,003	6.5	178	15	0	15
20	1,689	7.4	185	26	0	26
26	971	9.0	190	47	0	47
31	344	10.2	119	43	23	66
Moderately well drained:						
Stand 9:						
12	320	6.0	46	6	0	6
16	316	7.5	74	14	0	14
22	316	9.2	112	30	0	30
27	208	10.2	99	32	11	43

is the fusiform rust disease (*Cronartium fusiforme* Hedgec. and Hunt) (*26, 42*). This fungus causes cankers on branches and trunks of saplings and pole-size trees. It is not very destructive in the natural stands of south Georgia and north Florida, but it has tempered the optimism regarding plantations in some parts of the range of slash pine, particularly in southern Mississippi (fig. 12). Fusiform rust is likely to be especially prevalent where slash pine and oaks grow together (*25*). It may conceivably become a factor of major importance in south Georgia and north Florida.

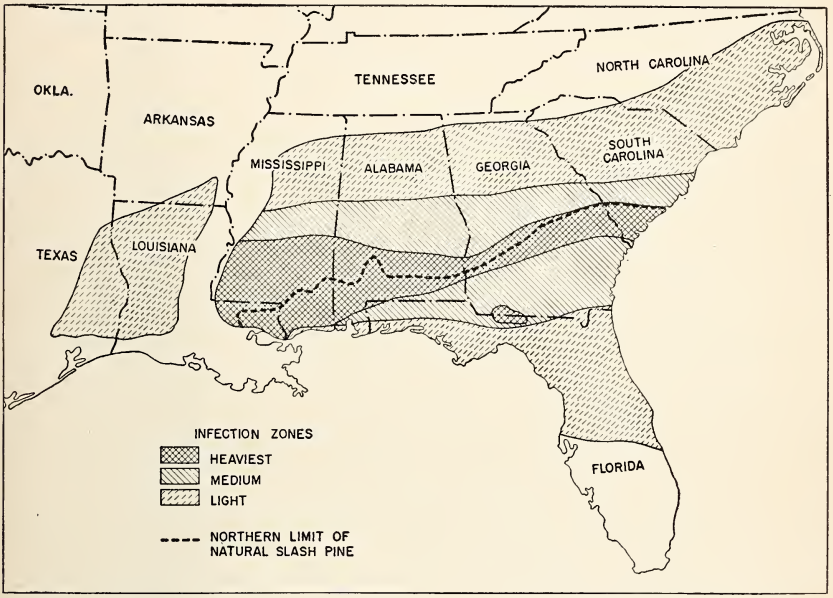


FIGURE 12.—Severity zones of fusiform rust infection in the South. (After Lamb as revised by Siggers.)

Young slash pine is also attacked by the pitch canker fungus (*Fusarium lateritium pini*), which kills leaders, branches, and trunks of small trees. Pitch cankers are characterized by a copious flow of gum. This fungus is distributed rather widely but it is not a serious hazard in management of slash pine.

Prescribed burning results in little damage if burning is carefully done when the trees are 15 to 20 feet or more in height. Fire may reasonably be prescribed for smaller stands but damage will increase with decreasing height.

Treatment of Young Unmerchantable Stands

Where there is abundant seed, slash pine often establishes stands of reproduction having several thousand stems per acre. Obviously, so many saplings cannot reach merchantable size on an acre, and none of them will without natural or artificial thinning. If effective, natural thinning is cheaper because no outlay for wages is necessary. It occurs in dense stands as the more aggressive individuals take

command and crowd out their neighbors. With slash pine this may be a slow process. An example is a stand on the Olustee Experimental Forest which had an original density of about 5,000 stems per acre. After 18 years 1,190 are still left and none of them is in vigorous growing condition. The average diameter is only 4.5 inches and the stand will not yet support a commercial pulpwood cut (fig. 13). Similar stands are causing concern on the Osceola National Forest. The trees are 20 to 25 years old and the crowns are becoming shorter each year, but thinning for pulpwood it still not practicable, according to operators who have tried it. Small trees are expensive to cut, and unmerchantable stems make trucking difficult because roads must be cleared through dense groups of small trees.

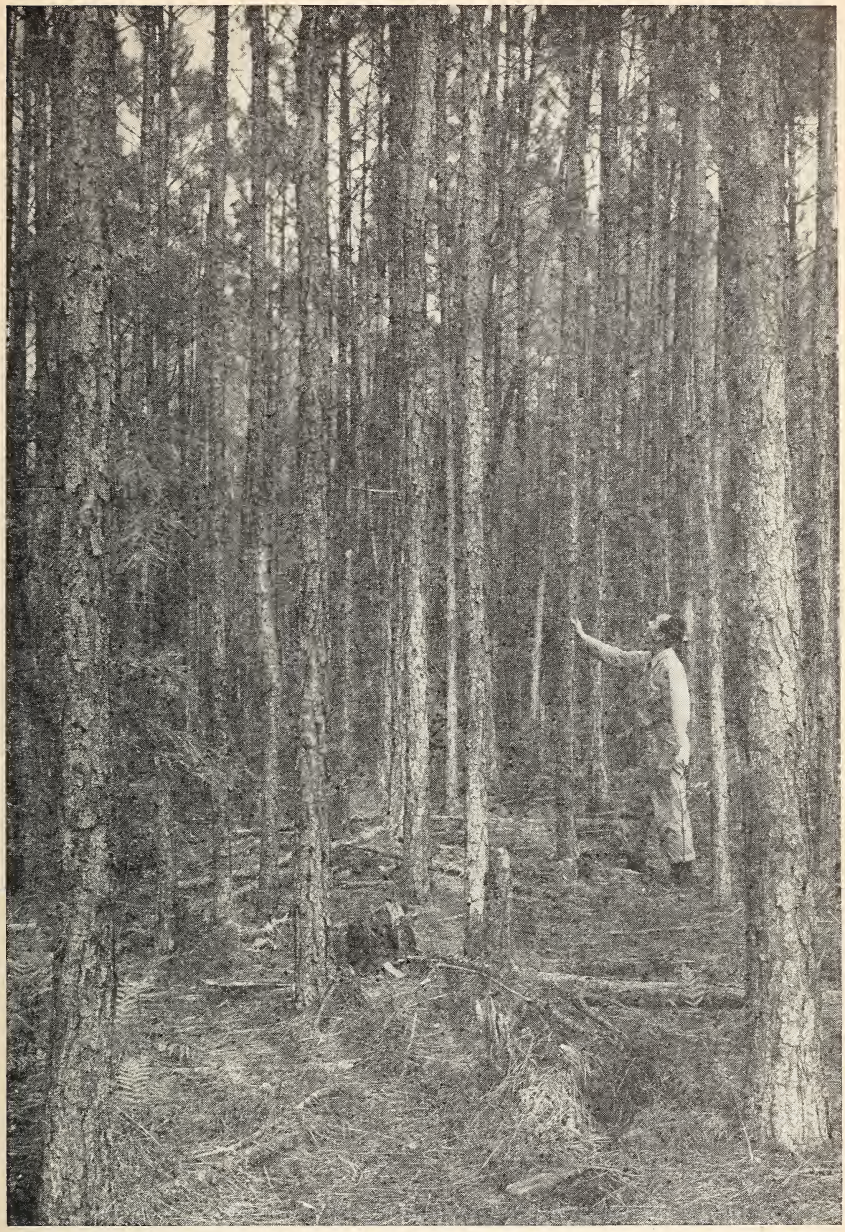
The foregoing examples illustrate what is common knowledge in the flatwoods—that failure to thin slash pine thickets sometimes results in conditions definitely undesirable for naval stores production and perhaps for wood production. To prevent this, naval stores operators started using their labor for nonrevenue thinning early in the development of the new slash pine forest. Wages were low and almost any treatment has proved very profitable. The objective was to produce a stand of dominant trees suitable for turpentining. Before the start of the Naval Stores Conservation Program in 1936, trees as small as 7 inches in diameter were included in this category (*41*), and many people thought that a residual stand of not more than 300 trees per acre was about right (*2*, *9*, *18*). The trend since then has been toward heavier residual stands, largely because the pulpwood market makes commercial thinning possible in stands of smaller diameter. The number of trees left in more recent precommercial thinnings on private lands approaches 600 per acre.

The usual practice has been to start a crew with axes or brush hooks through the woods in a line, thinning all stands above the desired density on the strip covered. From 15 to 25 feet in height was considered the optimum size range for an efficient job (*9*). Costs reported for this type of operation have been variable, ranging from two to six or more man-hours per gross acre. Cost for treated acres would probable be at least double that for gross acres.

As wages for common labor have increased in recent years, the expense of nonrevenue thinning has led forest owners to seek other, cheaper means for doing this job. The best mechanical prospect so far is a heavy, water-filled drum similar to a cornstalk cutter that knocks down and chops up all the trees on a strip 6 to 8 feet wide (fig. 14). A crawler tractor pulls this piece of equipment, clearing parallel strips through dense reproduction, leaving 2 feet or more untouched between the cleared strips. Preliminary figures indicate a cost per acre about half that for thinning by hand. Some of this advantage is lost because the machine is not highly selective and, even if small, lightly stocked areas lie within larger blocks of dense reproduction, the tractor operator still must give the whole area the same treatment.

RESULTS OF EXPERIMENTS IN PRECOMMERCIAL THINNING

In general, the objective of nonrevenue thinning in slash pine has been to reduce in one operation the number of stems to the point where there will be no need for futher thinning before a commercial cut is



F-453383

FIGURE 13.—A dense stand of slash pine saplings, 20 years of age, in need of thinning. The trees are still too small to provide a commercial pulpwood cut. Mortality from competition is gradually thinning the stand naturally. This stand received no precommercial thinning. (Compare with figure 17.)

875202°—50——4

F-43391

FIGURE 14.—Dense slash pine saplings after thinning with a brush cutter. The next operation planned is a commercial thinning for pulpwood 10 to 15 years hence.

possible or before the trees are large enough for turpentining. When there was no market for pulpwood this meant reducing the stand so that remaining trees could reach naval stores size in good condition to yield gum.

Early thinning studies reflect this market condition by having as their only objective the production of a full stand of good turpentine trees. For this purpose the estimate of 300 trees per acre, which was often used as a standard for early thinning, appears to have been about right. On a good (90- to 95-foot) site at Raiford, such a thin-

ning in 16-year-old slash pine produced a good stand of turpentine trees 15 years later.[5] The largest third of the trees averaged almost 11 inches in diameter and their crowns were in good condition for gum production.

The check plot with which thinned plots were compared at Raiford shows that volume production was severely curtailed by drastic reduction of the number of stems down to about 300. This same result has been substantiated in other studies on more nearly average sites. There has also been a good pulpwood market for thinnings during the past several years. For these reasons, later studies have been aimed at integrated production of gum and wood products more than at production of one to the exclusion of the other. In effect, this has meant that the objective of thinning is to produce a stand ready for pulpwood thinning while the trees are young and vigorous enough to respond quickly to release. If this is successfully accomplished, naval stores requirements can be met by controlling stand density through pulpwood thinnings.

A group of thinning studies in young slash pine has shown that trees of the right size for efficient thinning, (less than 3 inches) respond promptly to release from competition.[6] The response is conditioned somewhat by original density. Trees in very dense stands have profited from additional growing space somewhat more slowly after thinning than those not quite so crowded. This difference is not enough, however, to affect practical application of research results. If thinning is really needed, the same treatment will put stands of both medium and high density in good condition for the first commercial cut.

Trees on thinning plots near Cogdell, Ga., on a typical flatwoods site which produces a heavy growth of grasses, gallberry, and palmetto, were thinned when 10 years old. There was a wide range of original and residual densities. Plots which had 600 to 800 trees per acre after thinning will be ready for a pulpwood thinning 10 years after treatment, where the original density was less than 5,000 stems per acre. Where the original stand was extremely dense (40,000 to 50,000 stems per acre), 15 years will be required.

Plots on similar sites on the Olustee Experimental Forest, some of which have received their first commercial thinning, produced fine stands of vigorous pulpwood-size material 12 years after being thinned to 700 trees per acre. On comparable unthinned plots the trees are appreciably smaller, the crowns are short, and the stand is too dense to allow harvesting of pulpwood without cutting roadways.

PRECOMMERCIAL THINNING PROBLEMS

It is much more difficult to decide which stands need thinning than to prescribe a suitable treatment once that decision is made. Blanket coverage of a forest with a thinning crew is wasteful, as many stands which could develop successfully without being touched are thinned.

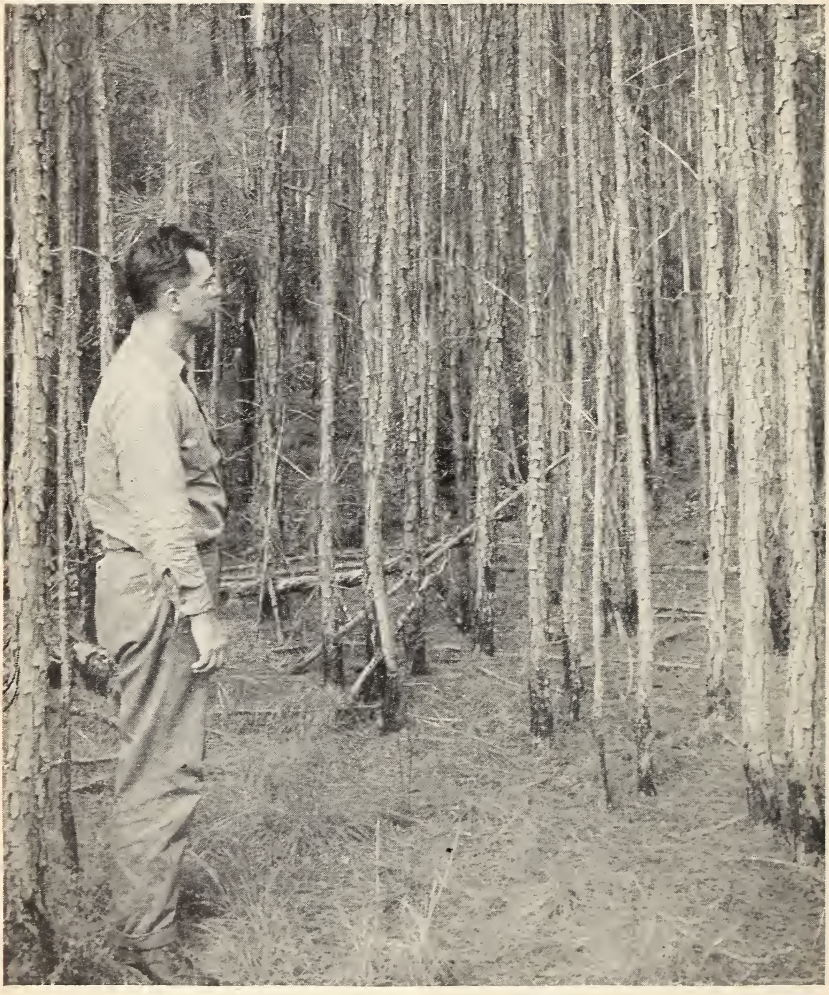
---

[5] BULL, HENRY. PROGRESS REPORT ON THE 1945 REMEASUREMENT OF THE RAIFORD THINNING PLOTS. 7 pp. 1946. [On file at the U. S. Forest Serv. South. Forest Expt. Sta.]

[6] BULL, HENRY. PROGRESS REPORT ON THE 1946 REMEASUREMENT OF THE 0–78 THINNING PLOTS NEAR COGDELL, GA. 17 pp., illus. [On file at U. S. Forest Serv. South. Forest Expt. Sta.]

By eliminating these more open stands, man-hour expenditures can ordinarily be cut a third or more.

A small average diameter and little variation from the average are requirements for efficient thinning (fig. 15). Heights must also be



F-453395

FIGURE 15.—Slash pine saplings of proper size and density for fairly efficient precommercial thinning. Trees smaller than those shown can be thinned more economically.

fairly uniform. The number of stems per acre is important, but only if the diameter and height requirements are met. The many acres of 2½- to 4-inch saplings which have so far received no treatment are extremely expensive to thin by hand and are hard on heavy equipment used in mechanical thinning, particularly where there are many 4-inch trees. In most cases the opportunity has passed for any eco-

nomical solution to the problem of competition within groups of trees in this class. Another consideration is that a 4-inch tree will soon make pulpwood, even where competition is fairly heavy.

RECOMMENDATIONS FOR PRECOMMERCIAL THINNING

Bull (*7*) prepared recommendations for thinning young slash pine based on all the study plots within the range. His table of recommendations (table 2) covers precommercial thinning in stands where the larger trees, excluding those abnormally large, average as much as 4 inches in diameter. Owners of large tracts will probably not be justified in thinning where stands approach the upper size limit, because labor costs will be high. A farmer working in his own woodlot, however, may be able to use some of the trees cut down and will benefit from the earlier cash returns resulting from the thinning.

Where the trees are small, a residual stand of 600 to 800 stems per acre appears to be more satisfactory for integrated production than other densities which have been left on experimental plots. Leaving less than 600 stems produces larger trees at an earlier age but at the expense of volume growth per acre. Residual stands heavier than 800 trees per acre are less likely to reach the size for commercial thinning in good condition for later growth (fig. 16). Quality of the site should influence the decision on the number of trees to leave. Fewer stems should be left on poor than on better soils.

F-301121

FIGURE 16.—Slash pine saplings thinned to 900 trees per acre. A slightly heavier cut would have left the stand in better condition for future growth. Fire was backed through the stand after thinning to reduce the hazardous accumulation of fuel.

TABLE 2.—*Recommendations for thinning young slash pine*

Approximate size of average dominant and codominant trees, wolf trees excluded		Recommendation	Approximate stand to leave if thinning is made		
Diameter breast high (inches)	Total height (feet)		Trees per acre	Basal area per acre	Average spacing
			Number	*Square feet*	*Feet*
Under 2½	Under 15	Thin only if (1) more than about 5,000 trees per acre and heights are very uniform, or (2) crown-length ratios [1] of dominant and codominant trees are under 40 percent.	600–800	Up to 25	7½–8½ (or D+5 to D+7¼).[2]
2½–4	15–30	Thin only if (1) more than about 1,500 trees per acre and heights are very uniform, or (2) crown-length ratios [1] of dominant and codominant trees are under 40 percent.	400–800	25–45	7½–10½ (or D+4½ to D+6½).
4½–5½	30–40	Thin only if (1) commercial or usable volume can be removed while leaving at least 45 square feet of basal area per acre in good dominant and codominant trees, or (2) crown-length ratios [1] of dominant and codominant trees are under 33 percent.	300–600	45–90	8½–12 (or D+4½ to D+6½).
6–8	40–50	Thin as soon as commercial or usable volume can be removed while leaving stand specified at right.	200–400	70–100	10½–15 (or D+4½ to D+7).

[1] Crown-length ratio of a tree is the percent of the total height made up by the live crown.

[2] Application of the D+rule of thumb spaces trees a distance apart in feet equal to the average diameter in inches plus a constant. For D+6 in a stand of 6-inch average diameter, spacing would be 12 feet.

Assuming that a residual stand of 700 stems is satisfactory and that the person in charge of a thinning job knows the type of stand he is going to treat, there are other factors which he must consider to do an efficient job. Perhaps most important is the distribution of slash pine reproduction. Because of limited seed sources in most areas, the dense stands that may need thinning occur as relatively narrow strips around ponds or as groups around seed trees. A small crew of six or less, with a man in charge capable of deciding where to thin and where not to thin, is usually more efficient than a larger one.

The distribution of scattered residual trees of sawlog size, and plans for their removal, may also influence the decision to thin. With good supervision, felling and skidding can be so planned that a reasonably good thinning results.

First Commercial Thinning

The purpose of the first commercial thinning is to produce income as the stand develops, and also to produce larger, better-quality stems for later utilization. As discussed here, it is a thinning where the larger trees in the stand are from 6 to 9 inches in diameter and employment of a commercial pulpwood producer is justified by the volume to be removed. Cutting salable products from stands where the trees are smaller may occasionally be possible on farms, but in the flatwoods where large ownerships predominate the volume thus removed is negligible. Thinning in the class of timber described is usually unnecessary where precommercial thinning was very heavy, leaving only about 300 trees per acre. In other stands, previously thinned or not, it is usually needed to keep the trees in good growing condition for later utilization for either gum or wood products.

Such cuttings have been made in slash pine on a limited area in the past because the acreage in stands of the right size was small, and the strong emphasis on naval stores precluded cutting trees approaching minimum diameters for chipping. Directions for thinning stressed removal of small understory trees and not more than 15 percent of the value (*1*). Recently, with integrated production an economic reality and with the rapid build-up of trees of the right size, more cutting to improve stand condition has been practiced. Usually thinning has been from below, the larger, dominant trees being left because of their more immediate turpentining possibilities. On some pulp company lands, however, many of the larger trees are cut to make way for their smaller neighbors. The wood from this type of operation is less expensive to handle than where only small trees are included in the cut. A few stands have been thinned by removing all the larger trees. This was necessary to provide an operable cut for the producer in stands where it appeared to be poor silviculture to delay thinning.

Experiments and Observations on First Commercial Cut

Investigations of the results of various types of thinning in pulpwood stands have been limited for the same reasons that little cutting of this type has been done in practice. The only formal research results are based on plots at Valdosta, Ga.,[7] and at the Olustee Experi-

[7] Bull, Henry. Final report on the Valdosta thinning plots. 10 pp. 1947. [On file at U. S. Forest Serv. South. Forest Expt. Sta.]

mental Forest. Thinnings at both places removed about a third of the cordwood volume. At Valdosta in a stand previously unthinned and very dense, the marking favored the better dominant and codominant trees, and all intermediate and suppressed trees over 4 inches were cut. The thinning was similar to that done on many forest properties. At Olustee the thinning was from above in a stand previously cut to 700 trees per acre in a nonrevenue thinning 12 years before (fig. 17). Rough dominant trees made up a large percentage of the volume removed. Trees in the lower crown classes were cut only if they were interfering with crown development of better trees or if they appeared to have a poor chance for survival till the next cut.

F-453384

FIGURE 17.—Twenty-year-old slash pine thinned precommercially at 6 years of age to 700 trees per acre and thinned again when 18 years of age by removal of 10 cords of pulpwood per acre. This stand is adjacent to that pictured in figure 13 and the trees are from the same seed crop.

The thinning at Valdosta did not affect the growth of the 100 largest trees left. It did stimulate growth of the smaller trees to some extent. The crowns of the larger trees benefited not at all. The thinning at Olustee is so recent that no statistics can be used to back up the following general observations. Within 2 years the openings in the crown canopy had been almost completely taken over by adjacent trees. This process was complete at the end of the third growing season. Increment cores show that the trees left have benefited slightly from the thinning. The Valdosta plots were left for 17 years without additional cutting. Those at Olustee need another thinning to prevent shortening of the crowns, 3 years after the first, which may indicate that more should have been removed in the first cut.

Observations in large pilot-plant thinning tests on the Olustee Experimental Forest help to round out the picture of the reaction of slash pine to treatment during its development in pulpwood-size stands. Increment cores taken periodically for as long as 5 years after cutting show that trees in the codominant and lower crown classes responded to release promptly, even after severe suppression, if they were given enough growing space. The dominant trees were often not visibly affected by cutting around them. A few showed faster growth. For a given crown class, the trees with longer crowns showed a greater response to thinning.

Removal of about half the volume from full stands in the first thinning appears to leave them in much better condition for future development than does a lighter cut. Experience in the Olustee studies also indicates that, whether emphasis in utilization will be on naval stores or wood products, a period longer than 5 years between the first and second commercial thinnings is undesirable.

TYPE OF THINNING NEEDED

Selection of the proper method of thinning is important because it determines to a great extent what future treatment must be. Removal of all the small trees in the first cut, as in thinning from below, lowers the unit value of the wood produced and reduces the possibility for future manipulation of the stand. Its principal objective is to save all the larger trees for naval stores. This, together with the salvage value of removing small trees about to die, is the justification for thinning from below. In contrast, thinning from above concentrates much of the cut in the larger diameters. Removal of limby dominants improves the quality of the stand and gives a type of product which is highly profitable for conversion into cordwood. The better trees in the upper crown classes are left for future growth. The thinning is extended down through the other crown classes; trees which should come out to improve quality and spacing of the reserve stand are removed. The principal disadvantage of this type of thinning is that trees close to naval stores size may have to be removed to meet the over-all objectives in the first cut.

For people interested in the long-term aspects of forest production, thinning in all crown classes to improve quality and growing space makes better sense regardless of the product objectives. Small trees are left to reach sizes that can be utilized more profitably. Followers of a more opportunistic policy may sometimes decide that the necessity for getting as many trees as possible into naval stores production at an early date outweighs these advantages.

RECOMMENDATIONS FOR FIRST COMMERCIAL THINNING

The best guide for timing the first commercial cut is probably the crown length of trees that would be left to make up the residual stand. If a stand is left unthinned until these crowns are reduced to less than 30 percent of the total height, recovery following thinning is likely to be slow. On the other hand, stands thinned when crowns occupy 40 percent or more of the total height lose production till the trees are again able to use the available growing space efficiently. All thinning should be aimed at developing or maintaining crown lengths on the trees in the main stand equal to 30 to 40 percent of their total height.

Bull's recommendations (table 2) for the type of thinning discussed here apply to stands where the average dominant and codominant trees are 6 to 8 inches in diameter. In the text accompanying the table he specifies leaving 80 to 110 square feet of basal area in larger timber. His recommendations apply only to the problem of spacing good growing stock. Improvement cuttings, to remove excessively rough, defective, or badly injured trees, may be needed also to put the stand in good condition for further growth.

The type of stand to be thinned in the first commercial cut may limit possible treatment. Where there has been no previous nonrevenue thinning and the trees have grown close together, the only choice may be between doing nothing or cutting most of the larger trees. Generally it is believed better to make the cut. Not to do so will result in production of slow-growing trees with short crowns, which are poor producers of either wood or gum.

Previously unthinned stands which are more lightly stocked offer fewer problems. The rough, limby, dominant trees should be taken out as soon as feasible, but, if naval stores cycles of 5 years or less are used, these trees in most cases may be chipped on at least one face before cutting without injury to the stand. Acid treatment of the streaks on such trees may help make the operation profitable (*12*).

Where a nonrevenue thinning has previously been made, leaving 500 or more stems, a third to a half the volume should be removed in the first commercial cut. At this stage in the development of the stand, a thinning cycle of more than 5 years is not recommended (fig. 18).

The effect of naval stores utilization is often to increase the volume of the first cut. Thinning must be heavy enough to provide not only room for additional growth during a regular thinning cycle but frequently also for an additional period while trees to come out in the next cut are being chipped. When wood is the only product such thinning leaves a more open stand than is desirable, but the small-crowned trees often found in denser stands are poor gum producers. Good gum yields can be expected from trees with 30 to 40 percent of their total height in live crown (*47*). Trees in the lower crown classes will not build up such crowns unless they are released and given adequate room when young.

The most productive flatwoods sites are margins of ponds and swamps, where pulpwood is inaccessible to the average producer except in dry weather. A special effort should be made to maintain stands in good growing condition on these better sites because they tend to

F-453389

FIGURE 18.—Twenty-nine-year-old slash pine thinned precommercially at 10 years of age to 555 trees per acre and not cut since. Faces have been chipped for one season on all trees above 9 inches in diameter and it will be 4 to 6 years before the first face is worked out. Competition will greatly reduce crowns on all trees if another face is worked before the first cut.

be overlooked in thinning operations if cutting plans are not well made. If maintained at proper density, stands on these sites will give excellent saw timber and high gum yields.

In stands that have fusiform rust cankers (fig. 19), thinning practice may have to be altered to reduce the danger of further infections and spread of those already present (*28*). Only stem cankers kill trees, and those that encircle more than half the stem are likely to cause death of the tree within 5 to 8 years. Branch cankers less than 18 inches from the trunk may develop into stem cankers and cause death within 8 years. Branch cankers farther from the trunk are

seldom dangerous. As heavy thinning increases the spread of fusiform rust by making the remaining trees more susceptible, it is often poor practice to remove all cankered trees. Recommended practice is to cut all trees which apparently will die before the next thinning, and then take as many less seriously affected trees as are needed to make an operable cut.

F-453891

FIGURE 19.—Fusiform rust canker on young slash pine. The canker involves the lower part of the trunk and the swollen part of the large branch, which in typical fashion has curved upward to parallel the trunk.

Further Commercial Thinning

Naval stores has dominated management in the flatwoods so completely that discussion of stand treatment in larger timber might be considered academic if it were not for the possibility of better integrating forest production. Under the system which has been used almost exclusively up to the present, no further thinnings are planned. A minimum diameter for turpentining, which was often 7 or 8 inches before the start of the Naval Stores Conservation Program and is now 9 or 10 inches, has been the only rule for selecting trees for harvest. An increase in diameter limit indicates progress, but, as has proved true for wood production, selection of trees based on diameter alone is a poor substitute for selection based on quality and spacing as well as size.

EXAMPLE OF LATER THINNING IN SLASH PINE STANDS

The Brinson plots, near Olustee, Fla., furnish an example of foresters' thinking on the later thinnings in slash pine stands. Representatives of the Florida Forest Service and the United States Forest Service cooperated in marking these plots as an example of good thinning practice. An objective of integrated production was assumed, with an ultimate harvest of high-grade sawlogs.

Two plots were established in a 25-year-old stand of slash pine on an old field. The first commercial thinning for pulpwood had been made 3 years before, when 10 cords per acre were removed. However, the first thinning had opened the upper crown canopy so little that another cut was clearly indicated. Marking started with removal of rough dominants and was carried on down through the lower crown classes (fig. 20). The objective was to free the better-quality stems for future growth into high-quality sawlogs.

The stands before thinning were alike in all respects, and marking did not change this similarity (table 3). None of the trees had pre-

Table 3.—*Summary of sample marking* [1] *on two plots in a 25-year-old stand of slash pine on an old field*

Item	Plot 1			Plot 2		
	Cut	Leave	Total	Cut	Leave	Total
Trees 4.5 inches and larger, number	130	135	265	105	140	245
Trees 7.0 inches and larger, do	105	105	210	95	120	215
Trees 8.0 inches and larger, do	80	90	170	75	85	160
Trees 9.0 inches and larger, do	55	55	110	35	35	70
Volume, cords	13. 8	12. 8	26. 6	10. 3	12. 4	22. 7
Basal area, square feet	58	54	112	45	54	99
Average spacing, feet	------	18. 0	------	------	17. 6	------
Average diameter, inches	------	8. 3	------	------	8. 1	------
Spacing factor [2]	------	2. 2	------	------	2. 2	------

[1] Marking was done 3 years in advance of thinning to permit turpentining of trees to be removed.

[2] A factor which, multiplied by the average diameter in inches, gives the average spacing in feet.

F-453390

FIGURE 20.—Marking for an intermediate thinning in 25-year-old slash pine on an old field. Crosses indicate trees to be left. Rags are tied around those to be cut. About half the volume will be removed in the thinning.

viously been chipped for naval stores because they were too small. Now, however, 35 or 55 faces per acre were available on trees 9 inches and larger that had been marked for removal. These would support a productive turpentining operation. Additional faces could be obtained by chipping trees of slightly smaller diameter. However, competition among crowns was becoming so severe that a major question was whether or not cutting should be deferred so that the trees to be removed could first be worked for naval stores. It was the judgment of the group that the trees to be turpentined should be worked for only 3 years before cutting. It was anticipated that at the end of that period the basal area in leave trees would have built up to ap-

proximately 65 square feet. After cutting there would be a 5-year period during which the trees left could take over the extra growing space before they might need thinning again.

Trees in the Brinson plots were spaced a distance apart in feet equal to a little more than twice their average diameter in inches. This checks with Newcomb's (*35*) finding that the same number of feet as double the diameter in inches is a good rule of thumb for spacing trees to be turpentined before cutting. This method of spacing leaves approximately 60 square feet of basal area in unturpentined trees. Because only 3 years was to elapse in this case before cutting, the basal area would not have time to build up to the level normally anticipated where faces are worked for 5 years or longer.

The Brinson plots were marked a little heavier than Bull has recommended for stands of similar diameter distribution (*7*). The two reasons for this are: (1) Improvement cutting was combined with thinning in the restricted sense, on which Bull's recommendations are based; and (2) more emphasis than he had allowed for was given to production of good turpentine trees.

RECOMMENDED PRACTICE FOR THE SECOND AND LATER THINNINGS

1. Base marking on the stand's requirements as shown by crown characteristics and stem distribution. Try to maintain or develop crown lengths of approximately 35 percent on trees in the main canopy.
2. Take out limby dominant trees, if still present, as more growing space for better trees is needed. If previous thinning has removed the large trees of poor quality, maintain crown space for the larger trees of desirable form by keeping the upper canopy open. Much of the volume will come from the upper crown classes in thinnings of this type applied to the average flatwoods stand. These trees are cheaper to handle because of their larger size, and they are more valuable for naval stores.
3. If trees are to be utilized for naval stores, when cups are hung, space trees to be left at distances equal in feet to double the average diameter in inches. Govern selection of trees to be turpentined by recommendations 1 and 2.

MARKING THE STAND

Few problems are connected with the application of reasonable silviculture to stands in the second and later thinnings. Some difficulty may be met where turpentining precedes cutting. Although it would be simpler and seemingly more economical to mark for cutting and then let the naval stores operator chip the larger marked trees, in practice this is not likely to be satisfactory. Marks fade, they are knocked off trees, and spacing is upset by death or injury of leave trees. Moreover, silvicultural information on which to base marking may be more complete when the cutting date comes around. As a general rule, therefore, two markings are necessary—the first, a designation of trees to be chipped; the second, coming at the end of the naval stores cycle, the addition of small trees about to die and those that should come out to improve spacing.

Pruning

Most of the good-quality slash pine logs currently being produced in the flatwoods come from pond margins and swamps. One reason for the superiority of logs from such sites is that the trees are older. Another is that these trees have had severe competition from neighboring pine, cypress, and hardwoods, which caused early pruning of the lower portion of the stem (*39*). The stands growing on drier sites are more open, so that natural pruning is much less effective. Artificial pruning is not extensively practiced in the flatwoods. The trees in a number of plantations have had the lower limbs removed to clear the trunk for naval stores operations, but seldom has any pruning been done to improve wood quality. This is short-sighted because the value of the wood is increased tremendously by a small investment in labor. On longleaf pine, Henry Bull (*6*) found that an open-grown tree 4 inches in diameter could be pruned to 16 feet in about 3 minutes. Slash pine can be pruned just as readily. Coulter found that removal of one-third of the live crown did not affect diameter or height growth of slash pine and that two-thirds of the crown could be removed with only a slight loss.[8] Boggess (*5*, p. 24) found that no reduction in growth resulted in the first 2 years after as much as three-fourths of the total height of the tree was pruned.

To be most effective, pruning should be done when the trees are about 4 inches in diameter. They average about 30 feet in height at that size, so that ample crown is left if the stem is cleared for one 16-foot log. The most efficient job is done in one operation with a long-handled pruning saw. Only trees that are to be held for the final harvest should be pruned, so that they will have an opportunity to lay on the maximum amount of clear wood. Where turpentining of pruned trees is contemplated, precautions that will permit use of the clear butt section for wood products should be taken.

Reproduction Cuttings

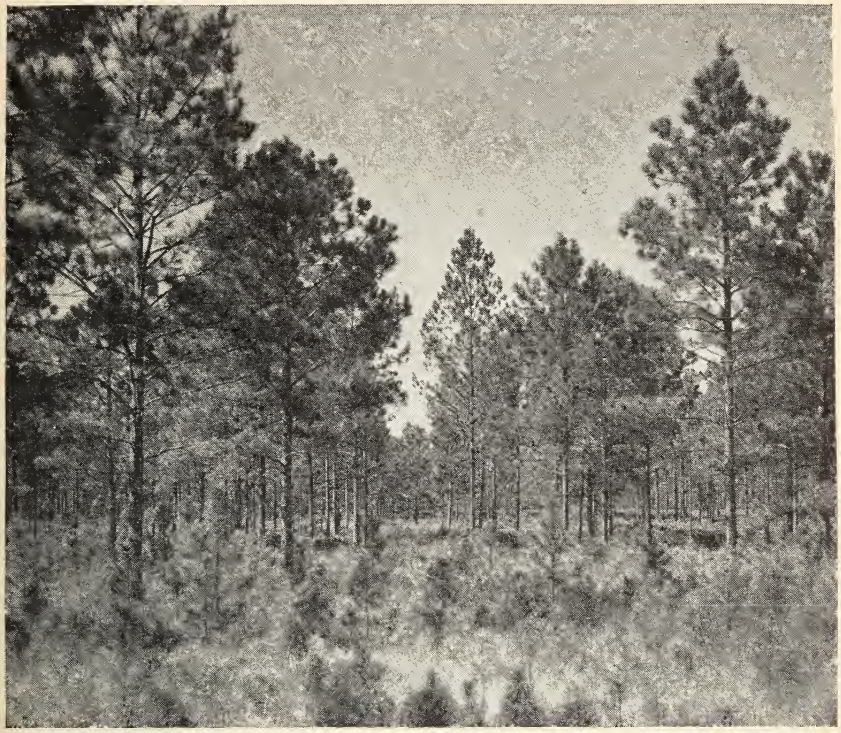
Stands of mature slash pine are not extensive because fire protection has come to the flatwoods so recently. Consequently there has been little need for information on methods of cutting in such stands. Where diameter-limit turpentining does not automatically mold the forest, however, a few stands are being cut to obtain reproduction and more will be cut as slash pine stands develop.

Two very different types of reproduction cutting may be done. In one type the mature trees are cut as they ripen, and their places are taken by reproduction already established underneath or by that which results from seed germinating in the openings. The resulting stand is composed of trees of all ages and sizes up to that considered mature for the kind of utilization being practiced. A similar type of cutting is done in such a stand each cutting cycle. Younger trees of poor form and those crowding their more desirable neighbors are added to the mature trees taken out to make way for reproduction. Reproduction cutting and thinning therefore become one operation.

---

[8] Coulter, C. H. The effect of pruning planted slash pines. 1 p. [Memo. on file at Fla. Forest & Park Serv. Tallahassee.]

A second form of forest may be developed by producing a uniform stand of reproduction on an area of 1 acre to 1,000 or more acres. Seed tree cutting produces such a stand if it is successful (fig. 21). So does shelterwood cutting, or strip cutting, or a number of other methods of regenerating an entire new stand. The thinnings described in previous sections are carried on in these stands as they



F–453387

FIGURE 21.—Reproduction under open-grown seed trees which are just 20 years old.

approach maturity. At that time the stand as a unit is cut to obtain reproduction. Continuous production is obtained from a forest managed in this way by maintaining a number of stands in a series of age classes from reproduction, through the intermediate sizes, to mature timber.

ADAPTABILITY OF SLASH PINE TO EVEN-AGED AND ALL-AGED CONDITIONS

Slash pine can probably produce good yields of naval stores and wood products in either even-aged or all-aged stands. Where complete protection from fire is to be practiced and trees are not to be turpentined, there is little scientific basis at present for favoring one type over another. However, the use of fire for protection appears to be out of the question in all-aged stands because of damage to young reproduction. Some seedlings, favorably located, will grow rapidly enough during a 5- or 10-year period to escape injury from fire prescribed just before the next cut. Many will not. Few land managers

will be content to sacrifice the reproduction which comes in late in the cutting cycle or that which has established itself under mature trees about to be cut. Turpentining operations are also probably less efficient in an all-aged forest because faces are scattered over the entire acreage instead of being concentrated, as they are in workable even-aged stands.

The relationship between fire and the form of forest is important. Complete protection for a few years results in an accumulation of

F–453385

FIGURE 22.—Slash pine reproduction in a small roadside opening surrounded by seed-bearing trees.

fuel which is extremely hazardous. There is a high risk and probability that severe losses of growing stock will be sustained from wild fire. This is one of the reasons why all-aged management has not been accepted by flatwoods landowners.

For all-aged stands the harvesting of individual mature trees or small groups of trees seems to be adaptable because slash pine has shown ability to seed in under a moderate overstory and to fill openings as small as one-tenth acre with reproduction (fig. 22). Greater tolerance of competition for moisture and light is probably not a prerequisite for all-aged management.

An adequate number of slash pine seed trees left after cutting can be depended on to produce an even-aged stand of seedlings. However, the reproduction is often excessively dense, so that a nonrevenue thinning is needed. A shelterwood of as many as 50 trees per acre (fig. 23) may help meet this problem. Slash pine will seed in under such an overstory but usually not in dense thickets. Removal of the shelterwood when saplings are 4 to 6 feet tall provides a thinning as a result of logging damage, which can be controlled by supervision. The shelterwood trees may be turpentined while they are seeding in the new stand and thus produce a good income during a period when there is little monetary yield under the seed tree system.

SEED PRODUCTION AND DISTRIBUTION

The seeding habits of slash pine favor natural reproduction. Open-grown trees may start producing seed when only 12 to 15 years old, and at 30 to 40 years of age this pine can be counted on for some seed almost every year, with fair to good production every 2 or 3 years. Trees left in the open after logging on the Olustee Experimental Forest have produced abundantly. Cones generally open during the latter half of September and, if there is enough soil moisture, most of the seeds germinate within 2 weeks after they fall.

Slash pine seeds are light (13,000 to 16,000 per pound) and, it is said, travel enormous distances in the wind. It is true that the scattered seedlings which become established at great distances from seed trees are welcome extensions of slash pine reproduction, but prompt regeneration of full stands requires a well-distributed fall of seed which, according to present information, can be depended on only within a short distance from seed trees. Moreover, a count of reproduction around an isolated 60-foot seed tree on the Olustee Experimental Forest did not indicate wide seed distribution. A few seedlings were found more than 250 feet from the tree, but adequate reproduction (600 per acre) extended no more than 100 feet. Only widely scattered seedlings were found beyond 130 feet. Distribution of seedlings around the tree was fairly uniform, with no apparent differences attributable to any prevailing wind direction. This pattern of seedling distribution does not typify general opinion in south Georgia and north Florida, as foresters and landowners generally believe that seed dispersal in some localities is influenced by prevailing winds. The area had been protected from fire for 3 years before the seedlings were counted, but the earlier fire history is not known. As most of the seedlings were less than 3 feet tall, it is probable that seed from three cone crops had produced the seedlings counted.

Siggins (*43*) studied the rate of descent of conifer seeds and described the variable distribution resulting from wind gustiness, wind

F-453388

FIGURE 23.—Reproduction under an open-grown shelterwood of 30 trees per acre. The overstory should be removed within 3 to 5 years, depending on growth of the seedlings, so that there will be little interference with development of the new stand.

direction, topography, and other factors. He states that distribution sometimes exceeds the commonly accepted rule of thumb that adequate numbers of seeds are scattered a distance equal to tree height.

That an effective seeding distance of 100 feet may be a good estimate for slash pine in the flatwoods is supported by observations of seedfall from 2 crops of cones on the Olustee Experimental Forest.

SEED TREE REQUIREMENTS

Where seed trees individually disperse seeds effectively to a radius of about 100 feet, the area beyond will not be satisfactorily reseeded except possibly in years when the seed supply is unusually abundant. It is therefore essential that seed-bearing trees be left fairly well distributed. In years when the cone crop is good, two trees per acre should be enough to establish a well-stocked stand. More will be

required in less abundant seed years. For average conditions, a recommendation has been made that 2 to 4 unturpentined trees 10 to 12 inches or more in diameter be left to keep slash pine lands reasonably productive (*14*). For the prompt regeneration required in more intensive management, additional trees may be necessary (fig. 24). Some of those selected may turn out to be relatively poor seed producers. Losses from lightning and other causes must also be anticipated. Extra trees will take care of such conditions and assure an abundant seed supply.

Where slash pine reproduction following removal of longleaf pine is desired, there are often not enough seed trees to assure prompt regeneration of full stands. Planting will be needed in such places if seed trees are scarce or absent. Where seed trees are present, but in small numbers or poorly distributed, a full stand of reproduction may require as many as 10 or 15 years to become established.

GROUND PREPARATION

Another problem is that of reproducing ponds and other brushy areas. On most sites preparation of the seedbed is not necessary for

F-453397

FIGURE 24.—Reproduction established under 40-year-old seed trees 5 years after cutting. Larger saplings were advance reproduction.

slash pine (*37*). Where heavy brush is a problem on pond margins and elsewhere seedbed preparation may pay dividends. Fire may be used successfully to kill back heavy brush in some places (*22*). A brush cutter similar to the tool developed for mechanical thinning may do the job in others. Use of such chemicals as 2,4-D is still another possibility. On good sites a reasonably high expenditure for regeneration may be justified.

SELECTIVE CUPPING PRIOR TO HARVEST

If naval stores operations are to precede the harvest cut, turpentining should be restricted so that seed trees of the right species will be well distributed with respect to areas needing reproduction. Seed tree cutting in a flatwoods stand, for example, may mean not only the reservation of enough trees of the right size, but also the saving of the few slash pines mixed in with longleaf at the expense of perhaps better longleaf trees. Selective cupping in such a case would mean cupping everything but those slash pines and whatever other trees were needed for seed. A similar type of selective cupping is needed before the harvest cut wherever an even-aged stand of reproduction is desired. Trees are selected to seed-in the new stand and everything else of operable size is worked before cutting (fig. 25). Seed trees that have been turpentined are not as good risks as round trees. Working one face

F-453394

FIGURE 25.—Preharvest turpentining with about 40 trees per acre (marked by crosses) left round. They will form the shelterwood when all other trees are cut.

on these trees in the last naval stores cycle is probably a good compromise in forests where emphasis is placed on naval stores production.

The principle of selective cupping would apply equally well to all-aged forests worked for naval stores. Openings should be made only where prompt regeneration of the right species is assured (fig. 26). Trees to be chipped on one acre might come from stands needing thinning in all stages of development and from large trees ready for harvest. Cupping would be confined to the trees to be removed.

F–453398

FIGURE 26.—Slash pine reproduction in a small opening at the edge of a pond. Seed trees are in the background. Clear-cutting in such spots is almost certain to result in prompt regeneration.

SUMMARY

Integrating the production of wood, gum, and forage is one of the main problems in the management of a slash pine forest.

Turpentining reduces diameter and height growth an estimated 25 percent while one face is being worked, and 50 percent while additional faces are being chipped. Use for naval stores also causes additional losses from mortality, jump-butt volume left in the woods, and increased woods costs. These losses may be reduced or even prevented by use of selective cupping, conservative chipping, removal of hardware from worked-out faces, short naval stores cycles, and prompt removal of faced trees.

Prescribed burning may be a profitable aid to protection where thorough analysis shows that benefits will exceed probable damage. Burning can best be done with a 3- to 10-mile northerly wind from December 15 to February 15. Spreading backfire rapidly, so that at least 10 acres will be burned per man-hour, cuts costs. Damage from prescribed burning may be reduced by burning only the area absolutely necessary, by avoiding cycle- or quota-burning, and by allowing 10 years of complete protection for development of reproduction.

Grazing is an aid to management because cattle reduce fire hazard. They eat and trample potential fuel, and may provide additional income. Potential income from them is so low, however, that without range improvements few concessions to benefit cattle are advisable.

Existing yield and stand tables are not entirely applicable to managed slash pine stands. Adjustments must be made. The estimated requirement for producing about 1 cord per acre per year on a short rotation is a growing stock of 15 to 20 cords. Approximately 5,000 board feet (Scribner) of growing stock should produce 250 board feet annually, in addition to naval stores, if intensively managed on a 60-year rotation.

The aim in treatment of premerchantable stands of slash pine is to produce a stand ready for pulpwood thinning while the trees are young and vigorous enough to respond quickly to release. A nonrevenue thinning may be needed to meet this objective where there are more than 5,000 stems per acre, where the larger trees are less than 2½ inches in diameter, and where the stand is uniform in height. Similar stands with less than 5,000 stems may need thinning if the crowns on the larger trees have been reduced to less than 40 percent of the total height. Precommercial thinning should leave 600 to 800 well-spaced trees per acre. The greater number would be left on the best sites.

The purpose of the first commercial thinning is to provide income as the stand develops, and also to produce larger, better-quality trees for later utilization. These objectives can best be reached by removing one-third to one-half of the volume from crowded stands, the exact amount depending on stocking and plans for future naval stores utilization. Marking should be done in all crown classes, taking rough dominants first and leaving all small understory trees that do not interfere with the crown development of better trees. The cut should include trees of intermediate size that ought to be removed to improve quality and spacing of the stand. Further thinning should be planned within 5 years.

Additional thinning may be needed to bring the final stand to the size desired in good growing condition. Silviculture in these later thinnings should be similar to that in the first commercial cutting. Any trees of poor form remaining in the stand should be removed. Crowns on the better trees should be maintained at about 35 percent of total tree height. Where trees are to be turpentined, selective cupping should be practiced. Spacing of those to be left after turpentining at D x 2 in feet produces what appear to be desirable conditions at the time of cutting.

At harvest, in stands to be turpentined, all trees except those to be left for seed are to be cupped and worked out. Excessively dense reproduction may be avoided by leaving a shelterwood of as many as 50 trees per acre, which should be removed when the saplings are 4 to 6 feet tall. The shelterwood method has the advantage of allowing an operable naval stores chance in the reserve trees.

LITERATURE CITED

(1) Akerman, Alfred.
1928. forest thinning. Ga. State Bd. Forestry Bul. 2, 10 pp., illus.

(2) ———
1929. thinning slash pine. Jour. Forestry 27: 714–719, illus.

(3) Bickford, C. A., and Curry, John R.
1943. the use of fire in the protection of longleaf and slash pine forests. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 105, 21 pp., illus. [Processed.]

(4) ——— and Newcomb, L. S.
1947. prescribed burning in the florida flatwoods. U. S. Forest Serv. Fire Control Notes 8 (1): 17–23, illus.

(5) Boggess, W. R.
1942. effects of pruning on young pine trees. Ala. Agr. Expt. Sta. Ann. Rpt. 30 pp.

(6) Bull, Henry.
1937. tools and labor requirements for pruning longleaf pine. Jour. Forestry 35: 359–364.

(7) ———
1949. recommendations for thinning young slash pine. Report of the U. S. Forest Serv. South. Forest Expt. Sta. 5 pp. [Processed.]

(8) Campbell, R. S., and Biswell, H. H.
1945. better management on southern coastal forest ranges. U. S. Dept. Agr., Agr. Inf. Ser. 17, 12 pp., illus.

(9) Cary, Austin.
1930. suggestions to furnish winter employment on turpentine farms of the south. Naval Stores Rev. 40 (33): 10.

(10) ———
1928. how the growth of trees in height and diameter is affected by working for naval stores. Naval Stores Rev. 38 (27): A–G, illus.

(11) Craig, Ronald B.
1949. rate of mortality in bark-chipped acid-treated turpentine trees. Forest Farmer 8 (12): 9, illus.

(12) Everard, W. P., et al.
1947. modern turpentining practices. U. S. Dept. Agr. Farmers' Bul. 1984, 12 pp., illus.

(13) Forbes, R. D., and Bruce, Donald.
1930. rate of growth of second-growth southern pines in full stands. U. S. Dept. Agr. Cir. 124, 77 pp., illus.

(14) ——— and Stuart, R. Y.
1930. timber growing and logging and turpentining practices in the southern pine region. U. S. Dept. Agr. Tech. Bul. 204, 114 pp., illus.

(15) GREENE, S. W.
1935. EFFECT OF ANNUAL GRASS FIRES ON ORGANIC MATTER AND OTHER CONSTITUENTS OF VIRGIN LONGLEAF PINE SOILS. Jour. Agr. Res. 50: 809–822.
(16) GEORGIA COASTAL PLAIN EXPERIMENT STATION.
1945. SUMMARY OF FINDINGS ON FOREST GRAZING PROJECT, 1940 TO 1944. Ga. Coastal Plain Expt. Sta. Ann. Rpt. Bul. 42, pp. 100–106.
(17) HALL, SHERWOOD J.
1928. SCIENTIFIC FOREST MANAGEMENT AS APPLIED TO TURPENTINE PRODUCTION. South. Lumber Jour. (n. s.) 32 (4): 43–45.
(18) ———
1929. FOREST MANAGEMENT FOR THE TURPENTINE OPERATOR. Naval Stores Rev. 39 (13): 16–17, 21, illus.
(19) ———
1929. THE LANDOWNER AND FOREST MANAGEMENT. Naval Stores Rev. 39 (34): 12.
(20) ———
1939. THE PLACE OF NAVAL STORES OPERATIONS IN FOREST MANAGEMENT. Jour. Foresty 37: 544–546.
(21) HARPER, V. L.
1937. THE EFFECT OF TURPENTINING ON GROWTH OF LONGLEAF AND SLASH PINE. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 64. [Processed.]
(22) HEYWARD, FRANK.
1939. THE RELATION OF FIRE TO STAND COMPOSITION OF LONGLEAF PINE FORESTS. Ecology 20: 287–304, illus.
(23) ——— AND BARNETTE, R. M.
1934. THE EFFECT OF FREQUENT FIRES ON THE CHEMICAL COMPOSITION OF FOREST SOILS IN THE LONGLEAF PINE REGION. Fla. Agr. Expt. Sta. Tech. Bul. 265, 39 pp., illus.
(24) KOEHLER, ARTHUR.
1938. RAPID GROWTH HAZARDS USEFULNESS OF SOUTHERN PINE. Jour. Forestry 36: 153–158, illus.
(25) LAMB, HOWARD.
1937. RUST CANKER DISEASES OF SOUTHERN PINES. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 72, 7 pp., illus. [Processed.]
(26) ——— AND SLEETH, BAILEY.
1940. DISTRIBUTION AND SUGGESTED CONTROL MEASURES FOR THE SOUTHERN PINE FUSIFORM RUST. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 91, 5 pp., illus. [Processed.]
(27) LEMON, PAUL C.
1946. PRESCRIBED BURNING IN RELATION TO GRAZING IN THE LONGLEAF-SLASH PINE TYPE. Jour. Forestry 44: 115–117.
(28) LINDGREN, RALPH M.
1948. CARE NEEDED IN THINNING PINES WITH HEAVY FUSIFORM RUST INFECTION. Forest Farmer 7 (12): 3, illus.
(29) LUFBURROW, BURLEY B.
1948. OLUSTEE WOODLOT GIVES GOOD ANNUAL INCOME. Naval Stores Rev. 58 (3): 26–28, illus.
(30) MATTOON, WILBUR R.
1929. SLASH PINE MIGRATING NORTHWARD. Jour. Forestry 27: 749–750.
(31) ———
1936. TWENTY YEARS OF SLASH PINE. Jour. Forestry 34: 562–570, illus.
(32) MCKELLAR, A. D.
1942. ICE DAMAGE TO SLASH PINE, LONGLEAF PINE, AND LOBLOLLY PINE PLANTATIONS IN THE PIEDMONT SECTION OF GEORGIA. Jour. Forestry 40: 794–797, illus.
(33) MESAVAGE, CLEMENT, AND GIRARD, JAMES W.
1946. TABLES FOR ESTIMATING BOARD-FOOT VOLUME OF TIMBER. U. S. Dept. Agr., Forest Serv., Unnumb. Pub. 94 pp.
(34) MUNTZ, H. H.
1947. ICE DAMAGE TO PINE PLANTATIONS. South. Lumberman 175 (2201): 142–145, illus.
(35) NEWCOMB, L. S.
1946. GROW LARGER TREES BY PROPER SPACING. The AT–FA Jour. 8 (12): 10–11, illus.
(36) NIELAND, L. T.
1945. TIMBER-GRAZING-GAME, A SUGGESTED COMBINED PROGRAM FOR UNCULTIVATED LANDS. Fla. Univ. Agr. Ext. Bul. 127, 19 pp., illus.

(37) Osborne, J. G., and Harper, V. L.
1937. the effect of seedbed preparation on first-year establishment of longleaf and slash pine. Jour. Forestry 35: 63–68.
(38) Paul, B. H.
1932. pulp yield increased in judicious selection of slash pine. Paper Indus. 13: 1311–1313, illus.
(39) ———
1938. knots in second-growth pine and the desirability of pruning. U. S. Dept. Agr. Misc. Pub. 307, 36 pp., illus.
(40) Rosenkrans, D. B.
1944. slash pine produces viable seed north of its natural range. Jour. Forestry 42: 685.
(41) Sessoms, A. K.
1928. the commercial value of slash pines in georgia. Naval Stores Rev. 38 (12): 25–26.
(42) Siggers, Paul V., and Lindgren, R. M.
1948. cronartium rust—new threat to slash pine. Naval Stores Rev. 57 (52): 13–14.
(43) Siggins, Howard W.
1933. distribution and rate of fall of conifer seeds. Jour. Agr. Res. 47: 119–128, illus.
(44) Squires, John W.
1947. prescribed burning in florida. Jour. Forestry 45: 815–819.
(45) True, R. P., and McCulley, R. D.
1945. defects above naval stores faces are associated with dry face. South. Lumberman 171 (2153): 200–204, illus.
(46) United States Forest Service.
1929. volume, yield, and stand tables for second-growth southern pines. U. S. Dept. Agr. Misc. Pub. 50, 202 pp., illus.
(47) ——— United States Bureau of Entomology and Plant Quarantine, and United States Bureau of Plant Industry.
1935. a naval stores handbook dealing with the production of pine gum or oleoresin. U. S. Dept. Agr. Misc. Pub. 209, 201 pp., illus.
(48) Weddell, D. J.
1939. extending the natural range of slash pine in alabama. Jour. Forestry 37: 342–343, illus.
(49) Ziegler, Edwin A.
1946. florida's forest land and forest industry. Fla. Univ. Econ. Leaflet 5 (5): 1–4, illus.
(50) ——— Spillers, A. R., and Coulter, C. H.
1931. financial aspects of growing southern pine, washington county, fla. Forest Serv. Bul. 7, 77 pp., illus.

ADDITIONAL REFERENCES

Barrett, D., and Shirley, A. R.
1938. forest management in georgia. Univ. of Ga. Agr. Ext. Serv. Bul. 466, 32 pp., illus.
Diller, Jesse D.
1943. a canker of eastern pines associated with atropellis tingens. Jour. Forestry 41: 41–52, illus.
Dorman, Keith W.
1946. the life history of slash pine. Natl. Container Digest 2 (10): 1, 4, illus.
Harper, V. L.
1944. effects of fire on gum yield of longleaf and slash pines. U. S. Dept. Agr. Cir. 710, 42 pp., illus.
——— and Bickford, C. A.
1937. the slash pine a "multiple purpose" valuable tree for the southeast. Internatl. Naval Stores Year Book, 1937–38: pp. 144–146, illus.
Heyward, Frank.
1937. the effect of frequent fires on profile development on longleaf pine forest soils. Jour. Forestry 35: 23–27, illus.
———
1938. soil temperatures during forest fires in the longleaf pine region. Jour. Forestry 36: 478–491, illus.

MATTOON, WILBUR R.
1922. SLASH PINE. U. S. Dept. Agr. Farmers' Bul. 1256, 56 pp., illus.

1930. SLASH PINE FOR REFORESTATION IN THE COASTAL PLAIN. S. C. Agr. Expt. Sta. Cir. 41, 15 pp., illus.

1942. PRUNING SOUTHERN PINES. U. S. Dept. Agr. Farmers' Bul. 1892, 34 pp., illus.

PESSIN, L. J.
1938. EFFECT OF SOIL MOISTURE ON THE RATE OF GROWTH OF LONGLEAF AND SLASH PINE SEEDLINGS. Plant Physiol. 13: 179–189.

PRUITT, AUSTIN AGNEW.
1947. A STUDY OF THE EFFECTS OF SOILS, WATER TABLE, AND DRAINAGE ON THE HEIGHT GROWTH OF SLASH AND LOBLOLLY PINE PLANTATIONS ON THE HOFMANN FOREST. 93 pp., illus. [Thesis on file at Univ. of N. C.]

WYMAN, LENTHALL, AND COULTER, C. H.
1936. FLORIDA NAVAL STORES. Fla. Forest Serv. Bul. 9.

ZIEGLER, EDWIN A.
1934. FINANCIAL ASPECTS OF GROWING SLASH AND LONGLEAF PINE IN APPLING COUNTY, GEORGIA. Unnumb. rpt. U. S. Forest Serv. South. Forest Expt. Sta. 62 pp. [Processed.]

APPENDIX

The following charts and tables are included for the use of landowners managing slash pine timber stands.

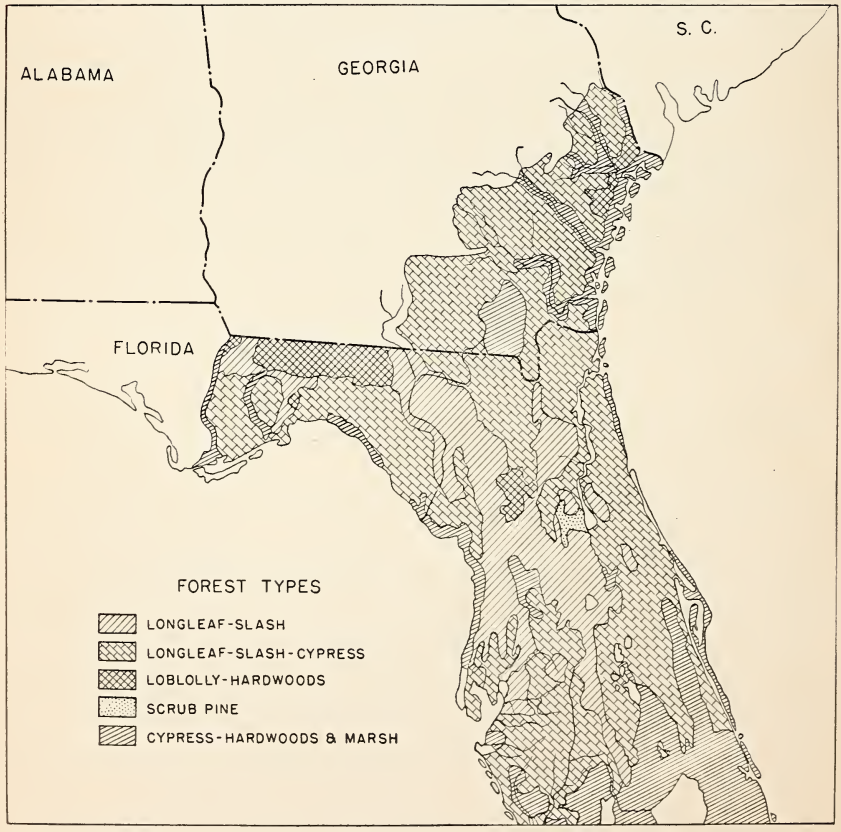


FIGURE 27.—Forest types in south Georgia and north Florida.

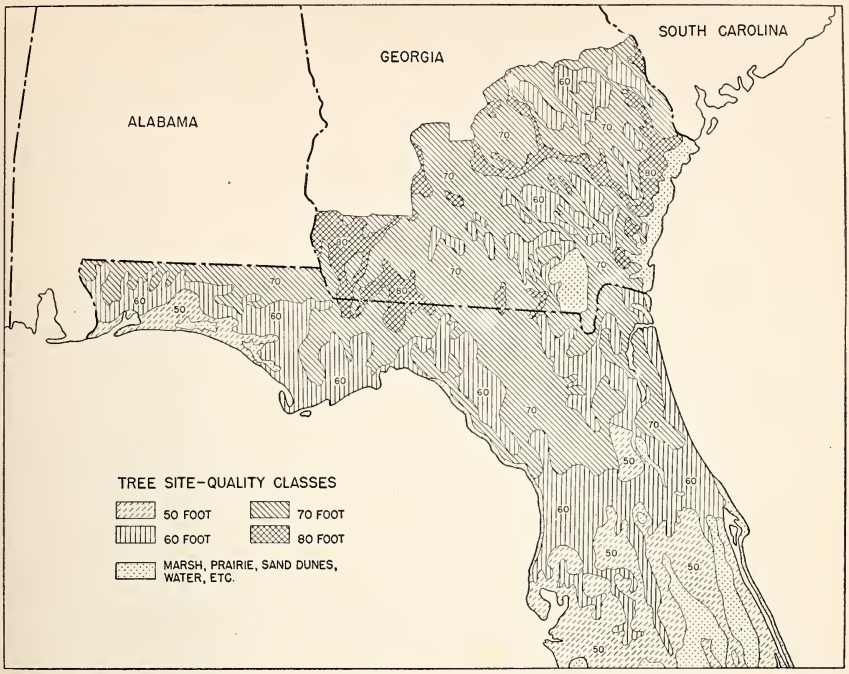


FIGURE 28.—Site quality as estimated from the average height of dominant trees at 50 years of age.

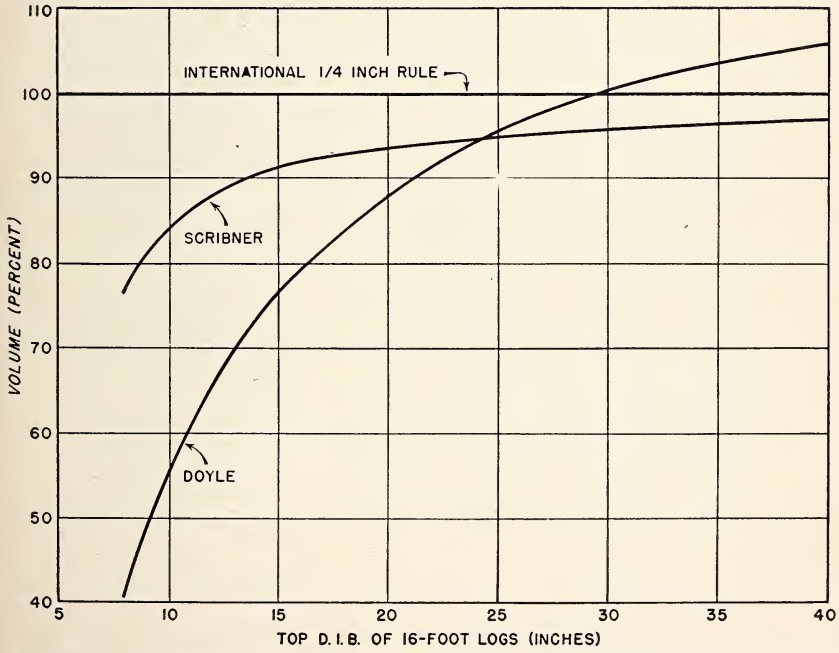


FIGURE 29.—Comparison of volumes obtained by scaling 16-foot logs of various sizes by three log rules. The International ¼-inch rule is used as a standard because it most nearly approximates lumber tally. (From Central States Forest Experiment Station, Station Note 47.)

TABLE 4.—*Normal yields, second-growth slash pine, by site index* [1]

Age [2] (years)	Total height, average of dominant and codominant trees	Trees 4 inches d. b. h. and larger					Trees 8 inches d. b. h. and larger	
		Stand per acre	Average diameter [3]	Basal area [4] per acre	Rough wood [5]		Yield per acre (Scribner decimal C rule)	Growth per acre per year (Scribner decimal C rule)
					Yield per acre	Growth per acre per year		
	Feet	*Number*	*Inches*	*Square feet*	*Cords*	*Cords*	*Board feet in tens*	*Board feet in tens*
60-Foot Site								
15	29	475	4.3	51	12	0.80		
20	36	835	4.7	99	20	1.00		
25	42	925	5.2	125	26	1.04	10	
30	48	810	5.7	139	32	1.07	105	4
35	52	700	6.2	146	36	1.03	245	7
40	55	615	6.7	151	40	1.00	410	10
45	58	550	7.1	153	43	.96	580	13
50	60	505	7.5	155	45	.90	750	15
55	62	470	7.8	156	47	.85	910	17
60	64	445	8.1	156	48	.80	1,050	18
70-Foot Site								
15	34	700	4.8	85	21	1.40		
20	42	840	5.1	121	28	1.40		
25	49	805	5.8	140	34	1.36	130	5
30	56	685	6.4	150	40	1.33	350	12
35	61	555	7.1	155	46	1.31	625	18
40	64	475	7.7	157	49	1.22	930	23
45	67	420	8.3	159	53	1.18	1,210	27
50	70	375	8.8	160	55	1.10	1,425	28
55	72	343	9.1	161	57	1.04	1,600	29
60	74	325	9.4	161	59	.98	1,740	29

80-Foot Site								
15	39	710	5. 2	101	27	1. 80		
20	48	765	5. 6	134	35	1. 75	90	4
25	56	675	6. 4	149	42	1. 68	335	13
30	63	555	7. 2	154	48	1. 60	730	24
35	69	440	8. 0	158	54	1. 54	1, 170	33
40	73	370	8. 8	160	58	1. 45	1, 515	38
45	77	325	9. 5	162	62	1. 38	1, 805	40
50	80	290	10. 0	163	65	1. 30	2, 035	41
55	83	270	10. 4	164	67	1. 22	2, 220	40
60	85	250	10. 8	164	69	1. 15	2, 360	39
90-Foot Site								
15	43	685	5. 6	113	32	2. 13	50	3
20	54	665	6. 1	141	41	2. 05	275	14
25	63	570	7. 1	152	48	1. 92	660	26
30	71	450	8. 2	157	54	1. 80	1, 230	41
35	77	350	9. 2	160	60	1. 71	1, 700	49
40	83	290	10. 1	162	66	1. 65	2, 060	52
45	87	250	10. 8	164	70	1. 56	2, 345	52
50	90	220	11. 4	165	73	1. 46	2, 590	52
55	93	205	12. 0	165	76	1. 38	2, 800	51
60	95	195	12. 5	166	78	1. 30	2, 960	49

[1] This table was assembled from tables 129, 137, 138, 139, 142, 143, 151, 152, Volume, Yield, and Stand Tables for Second-Growth Southern Pines (*46*). Sites are designated by the height attained on each by the average dominant and codominant trees in a 50-year-old stand. This height is called the site index. Thus a site with an index of 70 feet produces dominant and codominant trees averaging 70 feet in height at 50 years.

[2] Average age of dominant trees in stand. If age determinations are made at breast height (4½ feet from the ground), 3 years should be added to get total age. If they are made at a stump height of 1 foot, 2 years should be added.

[3] Diameter at breast height of the tree of average basal area.

[4] Cross-sectional area in square feet at the point of diameter measurement (4½ feet from the ground).

[5] A cord equals 128 cubic feet gross volume of stacked cordwood.

TABLE 5.—*Yield for 1 year of gum (dip and scrape) from slash pine trees* [1] *of different diameters* [2] *for good and poor sites*

Diameter breast high (inches)	Better than average sites		Poorer than average sites	
	Per tree	Per crop [3]	Per tree	Per crop
	Pounds	*Barrels* [4]	*Pounds*	*Barrels*
6	4. 7	108	3. 2	74
7	6. 1	140	4. 4	101
8	7. 5	172	5. 6	129
9	9. 0	207	6. 7	154
10	10. 4	239	7. 9	182
11	11. 8	271	9. 1	209
12	13. 3	306	10. 2	234

[1] Adapted from A Naval Stores Handbook, U. S. Dept. Agr. Misc. Pub. 209, table 8.
[2] Width of face equals one-third the circumference of the tree.
[3] 10,000 faces.
[4] 435 pounds.

TABLE 6.—*Gross volume* [1] *of tree, International ¼-inch rule*

FORM CLASS 76

Tree diameter [2] (inches)	Volume by number of usable 16-foot logs [3]				
	1	2	3	4	5
	Bd. ft.	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*
10	34	55	69		
12	52	85	110		
14	74	124	162	186	
16	100	169	226	267	
18	129	221	297	353	
20	162	279	377	449	507
22	198	344	467	560	639
24	237	415	567	676	785
26	284	500	684	826	959
28	331	585	806	971	1, 134
30	381	677	933	1, 125	1, 326

FORM CLASS 78

10	36	59	73		
12	56	92	120	137	
14	78	132	174	200	
16	106	180	241	285	
18	136	233	314	374	
20	171	296	401	480	542
22	211	368	500	603	691
24	251	441	605	723	840
26	299	528	725	877	1, 021
28	347	616	850	1, 027	1, 201
30	403	718	991	1, 198	1, 415

See footnotes at end of table.

TABLE 6.—*Gross volume*[1] *of tree, International ¼-inch rule*—Con.

FORM CLASS 80

Tree diameter[2] (inches)	Volume by number of usable 16-foot logs[3]				
	1	2	3	4	5
	Bd. ft.	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*
10	39	63	80	-------	-------
12	59	98	127	146	-------
14	83	141	186	216	-------
16	112	190	256	305	-------
18	144	248	336	402	-------
20	181	314	427	512	580
22	221	387	528	638	732
24	266	469	644	773	899
26	315	558	767	931	1, 086
28	367	654	904	1, 096	1, 284
30	424	758	1, 050	1, 272	1, 503

FORM CLASS 82

10	41	67	85	-------	-------
12	62	103	135	155	-------
14	88	150	199	231	-------
16	117	200	270	322	-------
18	153	265	359	430	-------
20	190	332	453	543	617
22	232	408	557	674	776
24	281	497	683	822	959
26	331	588	811	987	1, 151
28	388	693	961	1, 167	1, 371
30	447	801	1, 111	1, 350	1, 597

[1] Volumes were selected from Tables for Estimating Board-Foot Volume of Timber, by Mesavage and Girard (*33*). These volumes were chosen because Girard form class 78 is average for second-growth southern pine and a range from 76 to 82 should take care of most stands. (Girard form class is the percentage relationship between diameter breast high, outside bark, and top diameter of first 16-foot log inside bark.) The International ¼-inch log rule gives volumes that closely approximate lumber tally at many southern mills.

[2] Diameter is measured outside bark 4½ feet from the ground on the high side of the tree.

[3] Merchantable height is expressed in number of 16-foot logs in the merchantable part of the bole, the upper point of which is limited by branches, deformity, or minimum diameter. For smooth stems this minimum diameter is usually not less than 60 percent of tree diameter breast high for the smallest sawlog trees, usually 10 inches, or 40 percent for large trees, 30 to 40 inches in diameter. This definition of merchantability or usable log length must be carefully observed.

U. S. GOVERNMENT PRINTING OFFICE: 1950

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C. - Price 20 cents